Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

Rp
2

SEVENTEENTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
State College, Pennsylvania

1953

LIBRARY
APR 15 1954

FOR ADMINISTRATIVE USE ONLY

1953

Seventeenth Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania
Forage Crops and Diseases Section
Field Crops Research Branch
and
Eastern Section of Soil and Water Management
Soil and Water Conservation Research Branch
Agriculture Research Service
of the
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

For Administrative Use Only

B.

THE LABORATORY STAFF

R. J. Garber	Director
Vivian L. Troutman	Secretary

Project Leaders

V. G. Sprague	Agronomy
J. T. Sullivan	Plant Chemistry
R. R. Robinson	Soils
H. L. Carnahan	Cytogenetics
J. H. Graham	Plant Pathology

Assistant

Helen D. Hill	Cytogenetics

Part-Time Assistants

V. M. Held	Plant Pathology
F. L. Barnett	Cytogenetics
Simon Baker	Agronomy
G. H. Elkan	Soils
S. W. Braverman	Plant Pathology
R. B. Forbes	Soils
D. G. Routley	Plant Chemistry
Anna K. Storgaard	Cytogenetics

COLLABORATORS

B. A. Brown, Connecticut	M. A. Sprague, New Jersey
C. E. Phillips, Delaware	S. S. Atwood, New York
C. S. Brown, Maine	M. A. Farrell, Pennsylvania
A. O. Kuhn, Maryland	Irene H. Stuckey, Rhode Island
W. G. Colby, Massachusetts	G. W. Wood, Vermont
H. A. Keener, New Hampshire	G. G. Pohlman, West Virginia

* *

* This annual report of pasture research in the twelve Northeastern States is a progress report and as such may contain statements which may or may not be verified by subsequent experiments. The fact that any statement has been made herein does not necessarily constitute publication. For this reason citation to particular statements in the Report should not be published unless permission has been granted by the author. *

* The Report is prepared primarily for the official use of forage crop research workers in the Region and since it is mimeographed in limited numbers, it is not available for general distribution to individuals outside the Region. *

* *

D.

TABLE OF CONTENTS

Research at the Pasture Laboratory

Page

Introduction 1
Genetics, cytogenetics and breeding 3
  Alfalfa 3
    Breeding 3
    Selection of progenies of spreading and upright 3
    Inheritance of flower color in Medicago sativa 4
  Ladino clover 4
    Self compatibility 4
    Isolation of, resistant to Sclerotinia trifoliorum 5
    Selections for persistence at low light intensity 5
    Recombination of characters in Trifolium repens 5
    Inheritance of leaf coloration 6
  Meadow fescue and perennial ryegrass 6
    Hybridization of Lolium perenne and Festuca elatior . . . 6
    Inheritance of immunity from crown rust in diploid Festuca elatior 7
  Bromegrass 7
    Selection for increased seedling vigor in Bromus inermis . 7
    Karyological studies and interspecific relationships . . . 7
    Reaction of species to Pyrenophora bromi 8
  Orchardgrass 9
    Inbreeding in Dactylis glomerata 9
    Methods of evaluating progenies 9
    Resistance to foliar diseases 9
    Inheritance at diploid and tetraploid levels in dactylis spp 9
    Comparison of single crosses and advanced generation . . . 10
  Reed Canarygrass 10
    Phalaris arundinacea with 35 chromosomes 10
Plant Pathology 10
  Common leafspot and black stem of alfalfa 10
  Field inoculations of red clover with Sclerotinia trifoliorum 11
  Chemical control of Sclerotinia trifoliorum 11
  Physiological studies of Sclerotinia trifoliorum 11
  Root rot complex of red clover 11
  Red clover disease nursery 12
  Purple leafspot of orchardgrass 12
  Brown stripe of grasses 12
  Helminthosporium leaf streak of timothy 13
Physiology, biochemistry and soils 13
  Chemical composition of pasture grasses 13
  Carbohydrate studies on grasses 14
  Comparative protein content of orchardgrass clones 14
  Relationship of temperature and daylength to heading in grasses 15
  Regional microclimate studies 15

Cutting practices in alfalfa, carbohydrate reserves and persistence 16
Legume seedling establishment studies 16
Plant climate studies 17
Rate and frequency of potash applications on Dactylis glomerata 17
Responses of grasses vs. legumes to phosphorus and potassium fertilization 17
Ladino clover establishment in an old orchardgrass sod . . . 18
Irrigation of grasslands 18

Report of the Cooperative NE-10 Project

Adaptation, management and utilization of forage crops in the Northeast 19
The evaluation of forage crops varieties and strains for their use and adaptation in the Northeast 19

Pasture Research at State Stations

Connecticut (Storrs)
Alfalfa experiments 21
Fertilization 21
Varieties 21
Maintenance and improvement of pastures 22
Red clover varieties 23
Birdsfoot trefoil 23
Prevalence of Ladino clover and yields 23
Alfalfa for grazing 23
Herbicides and forage crop management 24
Quackgrass and sodium TCA 24
New seedings and weed control 24
Chemicals and pasture renovation 25

Maine
Breeding and evaluation of forage crops 25
Cutting management of Ladino clover 26
Chemical weed control in forage establishment 26
Grass silage preservation 26

Maryland
Orchardgrass breeding 27
Improvement of red clover 27
Development of Ladino clover 27
Testing grasses and legumes 28
Evaluation of grass for use with alfalfa for hay 28
Alfalfa seeding efficiency 29
Tall fescue management 30
Phenological studies 30
Fertilization of bluegrass pasture 31

Nitrogen fertilization of pure grass and grass legume association 31
Grass and legume combinations for beef production 32
Control of weeds in legumes 33

Massachusetts
Sources of fertilizer phosphorus for forage crops 33

New Hampshire
Variety testing of alfalfa, smooth bromegrass, Ladino clover and red clover 35
Breeding of smooth bromegrass, Ladino clover and red clover 36
Soil type and persistence of perennial legumes 37
Fertility needs of Ladino clover 37
Heavy fertilization, trace minerals and effect of feeding forage to dairy cattle 38
Maximum use of silage in feeding dairy cattle 39
Preservatives and carotene content of silages 39

New Jersey
Breeding alfalfa adapted to humid conditions 40
Effect of time of fertilizing alfalfa 41
Survey of quality of hay 42
Plant food combination and alfalfa 43
Response and nutritive value of grasses treated with nitrogen and potash 43
Effect of time of fertilizing birdsfoot trefoil 44
Plant food combinations and birdsfoot trefoil 45
Chopped green forage for dairy cattle 45
Utilization of pasture in production of beef 46
Milk producing potentials of silage 46
Horse pasture research 47
Chickweed control in alfalfa 47

Cornell University (New York)
Breeding and cytogenetic investigations with forage plants . 47
Evaluation of forage crops and varieties 49
Strain testing and breeding with emphasis on production during drought 52
Diseases of forage crops 54
Legume and grass seed treatment 54
Survey of diseases 54
European chafer studies 55
Clover root borer studies 56
Alfalfa snout beetle investigations 56
Biology and control of clover seed weevil 57
Insects of birdsfoot trefoil 57
Fungicides to preserve hay and grain 58
Irrigation and nitrogen fertilizer and yield of legume grass mixtures 58
Factors affecting seedling establishment 59
Stage of growth and yield, chemical composition and longevity of forage plants 60
Birdsfoot trefoil in New York 60

Pennsylvania
The genetics and improvement of red clover 61
The genetics and improvement of birdsfoot trefoil 62
The genetics and improvement of forage grasses 62
The genetics and improvement of alfalfa 64
Effects of soil compaction in permanent pastures 64
Renovation of unproductive pastures 66
Forage and grain production of winter small grains as influenced by fertilization and management practices 66
Yields of various forage species under irrigation 67
Grazing new strains of legumes and grasses in mixtures . . . 68
Fertilizers and forage production 68
Measurement of nutritive value of pastures and pasture plants 69
Evaluation of legumes and grasses for hay, silage and pasture 70
Forage insect investigations 71

Rhode Island
Management for maintenance and sustained yields 72
Breeding improved alfalfa 73
Soil fertility and soil moisture relations 74
Potash sources and ratios 75

Vermont
Cytogenetics and breeding of forage legumes 75
Trefoil strain trials 76

List of publications 82

PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This Seventeenth Report is organized similarly to that of last year and contains discussions of research at the Pasture Laboratory, of progress on the NE-10 Project, and a summary of results at each of the twelve Northeastern state agricultural experiment stations. The collaborators were responsible for assembling and editing the reports from their respective stations; the report on the NE-10 regional project was submitted by the Chairman of the Forage Crops Technical Committee; and the material regarding activities at the Laboratory was prepared by the project leaders.

During the year several resignations and appointments occurred at the Laboratory. Drs. H. P. Binger and H. W. Indyk completed their graduate studies and accepted positions elsewhere, the former with the Vita-Zyme Laboratories of Chicago and the latter with the Delaware Agricultural Experiment Station. Five part time assistants were appointed, Richard Forbes and Gerald Elkan in soils, Douglas Routley in plant chemistry, Samuel Braverman in plant pathology and Anna Stergaard in cytogenetics, making a total of eight such assistants presently employed. They are also pursuing graduate studies at The Pennsylvania State University. Mrs. Vivian L. Treutman replaced Mrs. Pauline J. Phelps as Secretary. The Director of the Laboratory returned to the Staff on September 14, after spending a year with the Food and Agriculture Organization.

Dr. C. E. F. Guterman, Director of the Cornell University Agricultural Experiment Station who has been a collaborator with the Laboratory since it was organized, resigned during the year. He was replaced by Dr. S. S. Atwood, Professor of Plant Breeding and Dean of the Graduate School. We shall miss the prudent council of the former but are glad to welcome as a collaborator a former project leader at the Laboratory. Another collaborator, Dr. A. R. Midgeley, with several years of valuable service in the interest of cooperative forage crops research in the region has accepted a foreign assignment and in his place has been appointed Dr. Glen M. Wood of the Vermont Agricultural Experiment Station.

After a lapse of three years a collaborators' meeting was held at State College, Pennsylvania. It will be recalled that one of the two principal objectives in establishing the Pasture Laboratory in 1936 was that it serve as a focal point for developing cooperative forage crop research in the Northeastern region. Gratifying progress has been made, built largely on the friendly spirit of cooperation nurtured through the years by the Collaborators. This group, up to and including 1947, had held 9 regional meetings and sponsored eight others. More recently significant impetus has been given the regional approach to pasture problems by the Forage Crops Technical Committee appointed by the Directors of the state agricultural experiment stations. The scientists concerned with growing and breeding forage crops in the Region have developed effective cooperation. What is perhaps most needed at present is liaison between the plant and animal scientists. The economists too have an important role in attacking the problem of low cost production of animal products through forage crops.

The collaborators' meeting held June 9 and 10, 1953 was devoted largely to a discussion of current research at the Laboratory and an examination of plant materials and equipment. Following this meeting a short informal conference was held by the NE-10 group. Other regional meetings concerned with forage crops included the Eastern Alfalfa and Ladino clover conferences June 15 and 16 at Kingston, Rhode Island, Northeastern Forage Crops Technical Committee February 9 and 10 in New York City and October 5 and 6 at New Brunswick, New Jersey, and the Northeastern Soil Research Committee February 5 and 6 in New York City. Minutes of all these regional meetings were prepared and distributed to the participants.

RESEARCH AT THE PASTURE LABORATORY

GENETICS, CYTOGENETICS, AND BREEDING

1. Alfalfa

Alfalfa Breeding

Ratings on disease and reaction to leafhopper were obtained from the space-planted progeny test of plants distributed under NE-10 (1951 Annual Report, page 10). The progenies differed in these characters, with polycross progenies of the following clones outstanding:

Resistance to leafhopper yellowing	Resistance to Blackstem	Resistance to Yellow blotch
C-51	C-175	C-44
C-53	C-186	C-144
C-87		C-183
NY 49-38		C-221
		NY 49-50
		NY 49-57
		NY 49-58

Twenty-five plants selected from this planting on the basis of resistance to leaf diseases and leafhopper yellowing will be selfed and cloned for further evaluation.

Two 1951 nurseries consisting of 50 and 30 clones were observed and selections made on the basis of data collected. One of the clones will be included in an advanced Northeastern polycross. Seven clones with spreading growth habit were sent to Brawley, California for seed production of restricted polycrosses for evaluation in the Northeastern region.

Comparison of Progenies of Spreading and Upright F_2 Selections in Alfalfa

From seed produced in two isolations at Lincoln, Nebraska, polycross progenies of 6 spreading clones and 6 related upright clones were established. The progenies were planted 1 foot apart in each direction in six replications of plots 5' x 16' with an overseeding of S37 orchardgrass. Two management treatments will be superimposed and rate of spreading, yield and persistence of the progenies will be compared.

Inheritance of Flower Color in Medicago sativa

White flowered clones were selfed, intercrossed and crossed with clones heterozygous for flower color, and progenies are being grown for classification.

Ladino Clover

Self-compatible Ladino Clover

In 1947, 187 plants were established from a lot of Ladino clover seed which had been divided and previously subjected to three treatments. On the average 15 heads per plant were selfed. The average number of selfed seeds per head for the three groups of material was 4.1, 3.8, and 1.5 respectively. The range in number of selfed seeds per head in these same groups was 0-83.5, 0-24, and 0-13.5 respectively.

I_1 progenies (seed permitting) grown from the three groups of material were selfed in the greenhouse. The table summarizes the number of seeds per 5 heads on the I_1 plants of the three groups of material.

Number of seeds per five heads on selfed Ladino clover plants

	Total I_1 Plants	Classes				
		0	1-100	101-200	over 200	Av.
Check (Stored in Beltsville)	97	2	5	4	86	775
Target ship, Bikini	96	9	76	7	4	59
300 yards from target	21	8	11	1	1	62

Exceptional plants, namely, those with low self fertility in self-compatible families and those with high self fertility in self-incompatible families are being selfed again along with plants classified as self-compatible, intermediate self-compatible, and self-incompatible. Appropriate crosses are being made among these plants to study inheritance of self-compatibility in Ladino clover. In addition, self-compatible clones are being crossed with clones selected for resistance to Sclerotinia and clones with persistence at low light intensity in order to initiate an inbreeding program with the most promising breeding material at hand. The self-compatible clones are being crossed with clones exhibiting various anthocyanescent characters in order to facilitate genetic studies. Certain I_2 populations segregating for chlorophyll deficient seedlings will be studied for genetic ratios.

Isolation of Ladino Clover Resistant to *Sclerotinia trifoliorum*

The 250 clones selected in 1951-52 for resistance to Sclerotinia were included in a greenhouse test last winter in which 90 of the clones were selected for further study. These 90 clones were established in a polycross nursery to determine clonal performance in the field and to produce seed in 1953 for progeny evaluation. These clones and clones selected for persistence at low light intensity will be evaluated in New Hampshire, Maryland, and Minnesota. The clones differ in vigor, density of growth, length and width of leaflets, and rate of stolon elongation. Eight of the 90 clones have been selected for a synthetic.

In addition, the 90 clones have been increased vegetatively and four replications of 5 plants each have been planted in flats for a Sclerotinia test in the greenhouse. Two replicates have been inoculated with viruses in order to determine (1) any clones that may be resistant to virus and (2) the effect of virus on the reaction of the clones to Sclerotinia.

Stand counts were taken on the field material consisting of 87 single cross progenies and commercial checks which were established in 1952 and inoculated with Sclerotinia. The progenies differed significantly in percentage ground cover (survival) in April. The better progenies gave approximately 6 times as many survivors as commercial Ladino clover. However, there was essentially no correlation between field reaction of the 87 progenies to Sclerotinia in the field and their reaction in the greenhouse.

Ladino Clover Selections for Persistence at Low Light Intensity

The 29 clones selected for persistence at low light intensity were planted in a polycross nursery in 1953. Six of the clones showing good vigor and dense growth habit have been selected for a synthetic. These six clones were also included in the Sclerotinia and virus test described earlier.

Recombination of Characters in *Trifolium repens*

Nine plants were selected from this nursery for further study.

Inheritance of Leaf Coloration in Ladino Clover

Seedlings were grown at 50°F. in the greenhouse to obtain expression of the various characters. Crosses between similar phenotypes in the case of flecking, purple mid rib, or purple leaves consistently gave ratios approximating 3:1 or no segregation. Crosses of the above phenotypes with green plants gave ratios of 1:1 or no segregation. Progenies from crosses among the three phenotypes were difficult to classify and no interpretation could be made regarding the allelic relationships of genes conditioning the three characters.

Meadow Fescue and Perennial Ryegrass

Hybridization of Lolium perenne and Festuca elatior

A total of twelve 21-chromosome hybrids (perennial ryegrass 2x x meadow fescue 4x) was identified. These plants produced a few heads in the greenhouse and attempts to cross them with tall meadow fescue were unsuccessful. Meiotic behavior of the hybrids was studied and the most common condition observed in the limited number of analyzable figures was 7 bivalents and 7 univalents with no degeneration through the quartet stage. Most pollen grains were incompletely filled.

In order to obtain autoallopolyploids from these 21-chromosome hybrids and to study the effect of different percentages of colchicine, the following experiment was conducted. Twenty tillers from each of the 12 clones were divided into 4 groups of 5 each and treated for 12 hours with 0.1%, 0.25%, 0.5%, and 1.0% aqueous solution of colchicine. The 20 plants of each clone were transplanted to the field. In August the 240 plants were collected and 10 tillers from each were established singly in 4 inch pots. Chromosome numbers were determined from each of two root tips collected from each of the 2400 plants. The percentage of plants exhibiting doubling was 6.8, 8.0, 6.3, and 6.0 for 0.10, 0.25, 0.50, and 1.0% colchicine, respectively. These values were not significantly different. The fact that the amount of doubling in some clones was greater by a highly significant degree than in other clones, was of interest. The percentage of tillers exhibiting doubling for the various clones ranged from 0.5% to 18%. One hundred root tips were examined from untreated plants of the clone which gave the most doubling. No spontaneous doubling was detected.

Six additional root tips were examined from each of the 61 tillers in which both root tips exhibited doubling. In 14 of these, representing 6 of the 12 clones, all root tips showed 2N=42 chromosomes. Meiosis of these 42 chromosome plants will be studied and unrelated clones will be inter crossed. In addition, attempts will be made to cross them with tall meadow fescue (2N=42).

Eight viable seeds were collected from heads of the 21-chromosome plants which had been allowed to open pollinate. Seedlings from these have been established and their chromosome number will be determined.

The 21-chromosome hybrids as spaced plants appear more vigorous than either perennial ryegrass or meadow fescue. The heads exhibited some of the characters of both meadow fescue and perennial ryegrass. In the field, the 21-chromosome clones exhibited differential rust reaction. Rust was collected from meadow fescue, perennial ryegrass and susceptible hybrids for cross inoculation studies. Preliminary results suggest tha possibility of incorporating in the hybrid, meadow fescue resistance to perennial ryegrass rust and perennial ryegrass resistance to meadow fescue rust.

Inheritance of Immunity from Crown Rust in Diploid *Festuca elatior*

Four immune clones will be intercrossed in all possible combinations to produce a synthetic and for further evaluation. In addition, these clones will be crossed onto a susceptible clone in order to determine breeding behavior.

Bromegrass

Selection for Increased Seedling Vigor in *Bromus inermis*

The 115 plants selected for early and vigorous emergence in compacted soil in a greenhouse bench were established in a polycross nursery. Seed that will be harvested in 1954 from these clones and non-selected material will be used for a progeny test in order to study the effectiveness of the method.

Karyological Studies in Bromus and Interspecific Relationships

A karyological survey was made of several species of Bromus for the purpose of obtaining information that might facilitate interspecific hybridization studies. Included in the survey were 11 species in the Bromopsis section, four in the Bromium section, two in the Ceratochloa section, and one in Eubromus. Features involved in the study were chromosome numbers, meiotic behavior, and, to a lesser extent, aspects of chromosome morphology.

Chromosome numbers apparently recorded for the first time were: B. danthonia (2N=14), B. scoparius (2N=14), B. sibiricus (2N=28), B. tomentellus (2N=28), B. valdivienus (2N=42), and B. tectorum var. nudus (2N=14). Chromosome numbers as determined in these studies and at variance with those previously reported were: B. intermedius (2N=28), B. ciliatus (2N=28), B. anomalus (2N=14), B. erectus-like plants (2N=ca.70).

With the exception of B. tomentellus all diploid, tetraploid and hexaploid species were found to exhibit complete or nearly complete bivalent pairing at diakinesis and/or metaphase I. B. tomentellus, however, showed a variable number of quadrivalents. Octoploid and decaploid species exhibited variable frequencies of univalents, bivalents and multivalents. The multivalents ranged from trivalents to octovalents, with quadrivalents predominating.

Of 175 possible F_1 interspecific hybrids which were examined for chromosome numbers, 11 have been found to be triploids (2N=21). These plants were obtained from the following crosses: B. anomalus (2N=14) X B. frondosus (2N=28), B. anomalus X B. ciliatus (2N=28) and reciprocal, and B. frondosus X B. grandis (2N=14). A number of other F_1 plants from pollinations between species with like chromosome numbers appears to be hybrid but have not been definitely identified as such. Further crosses will be made and the pairing relationships of hybrids analyzed.

Reaction of Bromus Species to Pyrenophora bromi

Eighteen species of Bromus, some of them from several sources were inoculated with Pyrenophora bromi (brown leaf spot). The purpose was to determine possible sources of immunity or resistance so that some emphasis on interspecific hybridization could be directed accordingly. In general, species in the Bromopsis section were most susceptible, species in the Ceratochloa section somewhat intermediate, and species in the Bromium section more resistant. B. scoparius, B. japonicus, and B. tectorum var. nudus were highly resistant. All of these species are annuals and are not in the Bromopsis section. B. sibiricus, a species in the Bromopsis section, gave intermediate resistance. Efforts to hybridize these species and to cross them with 28-and 56-chromosome B. inermis will be intensified.

Orchardgrass

Inbreeding in Dactylis glomerata

Observations were made on reaction to foliar diseases on the I_6 and I_7 lines established in 1952. Though a rather high percentage of plants appeared to be natural out-crosses, 13 plants most resistant to foliar diseases were selected from lines showing highest self-fertility. Most of the inbred material is rather mediocre for resistance to diseases as compared with more recent selections from open pollinated plants.

Heterozygous clones selected specifically for disease resistance will be used to initiate a new inbreeding program. The prime objective in this case will be to develop lines homozygous for resistance or immunity to important foliar diseases.

Comparison of Methods of Evaluating Progenies of Dactylis glomerata

Yields and visual observations on vigor and disease were obtained in 1953 as in the previous year (1951 Annual Report, page 22). Data for the two years have been summarized. Selections for the composition of various synthetics will be made and polycross nurseries established in 1954.

Selection for Resistance to Foliar Diseases in Dactylis glomerata

Four replications of 10 plants each of 50 single crosses involving 12 parents selected for resistance to one or more foliar diseases were established in 1953. The 12 parent clones included both inbred and open pollinated selections. This material should provide a comparison of the effectiveness of selection within inbred and in open pollinated populations. At the same time, an attempt will be made to combine resistance to several foliar diseases.

Inheritance of Quantitative Characters at the Diploid and Tetraploid Levels in Dactylis spp.

Approximately 2400 plants representing the F_2 and both backcrosses of the cross Dactylis aschersoniana x D. woronowii were established in 1953. Though most of this material represented crosses at the diploid level, a few crosses at the tetraploid level were also included. Segregation for time of flowering, leaf color and head characters will be noted.

Comparison of Single Crosses and the Advanced Generation in Dactylis glomerata

Ten plants of each of 15 single crosses were brought into the greenhouse to produce advanced generation seed. This seed and the F_1 seed will be used to determine the amount of reduction in vigor that occurs in two-clone synthetics of orchardgrass made up from non inbred material.

Reed Canarygrass

Phalaris arundinacea with 35 Chromosomes

Limited open-pollinated seed from three 35-chromosome plants was avaliable. Open pollinated progenies of the three plants were grown and chromosome determinations made from root-tip sections. Chromosome numbers varied from 28 to 56. Leaf width determinations were made. The range in variation in leaf width was from 4 mm to 20 mm and this variation was independent of chromosome number. Meiotic studies on this material will be made in an attempt to determine whether the 7 extra chromosomes are homologous with P. arundinacea chromosomes or have a divergent origin. Phenotypic effects of extra chromosomes will also be studied and seed collected.

PLANT PATHOLOGY

Common Leafspot and Black Stem of Alfalfa

The emphasis of work on the foliar diseases of alfalfa was shifted to the development of homozygous resistant breeding material. In the spring of 1953 F_1 and S_1 seed from parents which showed varying degrees of resistance to the two pathogens were planted in flats of soil and the seedlings transplanted in rows in the field. Notes were taken throughout the growing season and plants showing little or no disease were brought into the greenhouse for further selfing and crossing.

Field Inoculations of Red Clover with *Sclerotinia trifoliorum*

Field experiments on the rate of application of dried grain inoculum of *Sclerotinia trifoliorum* (1952 Annual Report, page 9) were repeated and the data for the three years analyzed and published. Results indicate that the inoculum should be applied in November at the rate of 1 to 3 grams (2.5 to 7.5 cc) per square foot. In these experiments, more killing occurred from November inoculations than from those made in December. To determine the best time to inoculate, plots of red clover were planted in the spring and fall of 1953. Plots are being inoculated at 15-day intervals from August to May. This test will be repeated for several years.

Chemical Control of *Sclerotinia trifoliorum*

Established plots of Ladino clover are being sprayed with Pentachloronitrobenzene (PCNB) to determine its effect on *Sclerotinia trifoliorum*. One-half of the plots were inoculated with the pathogen in the fall of 1953. The chemical will be applied in the fall and spring.

Physiological Studies of *Sclerotinia trifoliorum*

Studies on the physiology of *Sclerotinia trifoliorum*, the causal organism of crown rot of clovers, are still in progress. Two strains of the fungus are being tested; a normal, virulent strain derived from a single ascospore, and a degenerate, avirulent strain which arose as a variant of the normal strain. The tests were designed to compare the relative ability of the strains to utilize organic and inorganic sources of nitrogen, response to certain B-vitamins during the initial phase of growth, secretion of protopectinase, and production of substances toxic to clover. Results are being examined for clues to an understanding of the host-parasite relation.

Root Rot Complex of Red Clover

The survivors from a group of red clover plants which had been inoculated one or more times with *Fusarium* spp. were polycrossed in the greenhouse in the spring of 1951 (1951 Annual Report, page 12). Seed from these plants and 11 varieties was planted in 3 x 5 foot plots in the spring of 1952. In September 1953, 20 plants from each plot were dug and the roots split and rated for insect and *Fusarium* damages. From over 2,000 plants examined only 74 had clean or slightly damaged roots. These plants were transplanted to pots in a warm greenhouse. Many of them died from injury and *Fusarium* and others were diseased with virus. Seventeen which remained healthy will be included in a new polycross.

Red Clover Disease Nursery

A red clover disease nursery was established in the spring of 1953. It consisted of replicated plots of 10 varieties and five selections made at New Jersey as part of the NE-10 project. Detailed disease notes will be taken in 1954 and 1955.

Purple Leafspot of Orchardgrass

Studies were completed and the results published on the effects of controlled periods of high and low humidities on the development of purple leafspot (Stagonospora maculata) of orchardgrass. These results may explain the increase of purple leafspot even during relatively dry periods. If spores are splashed onto healthy leaves by rain and the leaves dry before penetration occurs, growth of the fungus will be halted. Germination and growth will resume if a period of high humidity occurs within approximately 2 days. It is probable that over much of the Northeastern Region this requirement for moisture is fulfilled on most nights during the growing season. A relative humidity of 100 percent frequently occurs in a forage plant cover for 6 hours or longer at night even during periods of low rainfall. Two successive nights of high humidity are sufficient for moderate disease infection while 4 nights probably would produce epiphytotics equal to those produced after a protracted moist period. Several clones of orchardgrass which are highly resistant to S. maculata were selected for polycrossing in the greenhouse.

Brown Stripe of Grasses

A pathogen infecting the leaves of orchardgrass, timothy, tall oatgrass, Kentucky bluegrass and other grasses is Scolecotrichum graminis. The disease, known in the literature as streak, brown stripe, or leaf streak, probably reduces the yield and also lowers, somewhat, the protein content. Although the disease is widespread, only leaf symptoms and a description of the causal organism have been reported. In a study of the responses of S. graminis temperatures for sporulation, mycelial growth, and spore germination were determined by placing cultures or diseased tissue in temperature controlled ovens. A range of 20° to 25°C. was optimum. A method of producing spores in culture has also been devised. Infection is effected from spores gathered from diseased tissue, but not from mycelial cultures. Further studies will be initiated to determine whether spores from one host will infect other grass or whether physiological races or varieties are present.

The remnants of several lots of polycross seed of orchardgrass which were relatively free of leaf diseases (particularly brown stripe) in field plots were planted in the greenhouse and the seedlings inoculated twice with S. graminis. The seedlings which

remained free of disease were planted in rows in the field in the spring of 1952. In the fall of 1953 ten vigorous plants which were free of brown stripe and relatively free of purple leafspot, anthracnose, and rust were brought into the greenhouse to be polycrossed. Seed from these plants will be planted in plots and compared with other available strains of orchardgrass.

Helminthosporium Leaf Streak of Timothy

Studies are being continued on the previously unreported disease of timothy. (1952 Annual Report, page 8.)

PHYSIOLOGY, BIOCHEMISTRY AND SOILS

The Chemical Composition of the Pasture Grasses

(In cooperation with T. G. Phillips of the New Hampshire Station)

Studies have been continued on grasses growing in small plots (1952 Annual Report, page 11). Samples of eight species of grasses cut at grazing height throughout the two growing seasons of 1950 and 1952 are being examined chemically. Analyses have been made for protein, lignin, cellulose, and ash, and are being made for ether extract and crude fiber. During 1952 plot yields and the moisture content of the grass were obtained also.

Some of the 1950 data have been reported. In that year reed canarygrass and Kentucky bluegrass were relatively high in protein and timothy was low. In 1952 the high protein species were orchardgrass and tall oatgrass while the low ones were timothy, bromegrass and red top. Species low in lignin for both years were reed canarygrass and tall oatgrass. Reed canarygrass was low in cellulose both years and tall oatgrass was low also in 1952. Soluble ash, a good measure of the essential minerals, was highest in orchardgrass for both years but reed canarygrass, tall oatgrass, and fescue were close behind. The only species consistently low in ash were timothy and Kentucky bluegrass. The moisture content of the grass as cut in 1952 was highest in orchardgrass which had a yearly average of 77.0 percent. All other species contained over 72.0 percent moisture, as a yearly average, except Kentucky bluegrass which contained only 66.8 percent. Seasonal plot yields were highest with orchardgrass. Red top yielded highest per cut but as it was cut only four times was second highest in annual yield. Reed canarygrass was low yielding.

Plot yields and moisture contents were highest in the spring and lowest in midsummer. Summer grass tended to be higher in lignin and cellulose. Grass cut in September and October was much lower in cellulose than either spring or summer grass. The protein and ash contents were not consistently affected by season. Correlations among constituents are being determined.

Carbohydrate Studies on Grasses

Studies on the polysaccharides of forage grasses were continued (1952 Annual Report, page 10). The holocellulose prepared from orchardgrass was extracted with hot water and two concentrations of alkali and from each of these extracts hemicellulose precipitates were obtained by acidification, addition of alcohol, and evaporation to dryness. The total hemicellulose obtained amounted to 10 percent of the grass and of this 70 percent was from the water extract of the holocellulose. Those fractions considered the purest carbohydrate, having less contamination with other organic substances, were obtained by the alcoholic precipitation. When the hemicellulose fractions were hydrolyzed they yielded, in descending quantitative order, xylose, glucose, arabinose, galactose, and uronic acid, which were separated from one another by paper chromatography and measured by reflection densitometry. Fractions obtained by water extraction of the holocellulose were relatively higher in hexoses and lower in pentoses than those obtained by the alkaline extractions. From the relative abundance of the xylose and glucose it appears that the hemicelluloses of orchardgrass belong primarily to the xylose - glucose - glucuronic acid configurational group but some of the arabinose - galactose - galacturonic acid group is present.

A report entitled "The hemicelluloses of orchardgrass" was presented as a doctor's thesis to The Pennsylvania State University

Comparative Protein Content of Orchardgrass Clones

Early maturing species of grasses were higher in protein than late species when compared at the same stage of growth. An early and a late clone of orchardgrass differed in the same manner (1950 Annual Report, page 18). This relation of earliness and lateness to protein content was further studied in orchardgrass. Tops of 29 plants each of different clones in a space-planted nursery were harvested in the spring of 1953 when at the half-emerged stage and 37 were harvested when at full bloom. Protein was determined on each. The 8 earliest clones, with the date of the half-emerged stage as the criterion, reached that stage on May 13 and contained an average of 15 percent protein. The latest clone reached that stage on June 5 and contained 8.1 percent protein. The decrease of protein with advancing date was quite regular, the correlation coefficient between protein and date being -0.86. Using full bloom as the criterion a similar

relationship was found. The earliest clone to reach full bloom, on May 27, contained 8.3 percent protein and the latest, on June 22, 5.6 percent. The correlation coefficient between date and protein was -0.68. Both of these coefficients are highly significant. The plants were graded for leafiness. No relationships between leafiness and protein content or between leafiness and dates of maturity are evident.

Relationship of Temperature and Daylength to Heading in Perennial Grasses

The results of a heading study during the winter of 1952-53 were similar to those of the 1951-52 experiment (1952 Annual Report, page 18). The largest number of heads were produced when the following procedures were used. The plants were started outside in late August and moved into the greenhouse in late September. The greenhouse temperatures were maintained as near 50°F. as possible until early November when daylengths were increased to 16 hours. At temperatures of 65°F. under long days, the early and late strains of orchardgrass flowered most profusely. Bromegrass, timothy, tall and meadow fescue and reed canarygrass flowered best under long days at 75°F. Under short days and at temperatures of 75°F. all species headed poorly. When plants were moved from this treatment to long daylengths many sterile culms and few or no heads were produced.

Regional Microclimate Studies

In cooperation with A. Morris Decker, T. S. Ronningen and A. O. Kuhn (Maryland), E. R. Biel, J. E. Carson, and A. Vaughn Havens (New Jersey), H. A. MacDonald (New York), A. R. Midgley and K. E. Varney (Vermont) and G. G. Pohlman and E. L. Galpin (West Virginia).

During the relatively mild winter of 1953, precipitation was about normal or slightly above. Heaving was not serious. In March, precipitation was well above normal in New Jersey and Maryland, and in May, it was above normal in Maryland, and Pennsylvania. Rainfall became limiting during early June in West Virginia. By Late June and early July the lack of rain was limiting forage growth in all states. Rains in Vermont during August gave temporary relief but the drought continued severe in the other states into November. Vermont again experienced dry weather during October and November. Temperatures throughout the region were generally above normal with extremes of higher temperatures occurring during late June to early August over much of the region. These higher temperatures increased the severity of drought. It is suggested that any period without rain for one or two weeks should be considered as a drought. The amount of precipitation appeared to be of less importance than the interval between rains. The total monthly rainfall

loses much of its significance if the distribution of the rain is not considered. The interrelationship of temperatures, cloudiness and the prevailing dewpoints may warrant closer study in evaluating plant growth responses during periods of limited rainfall.

Cutting Practices as They Affect Carbohydrate Reserves in Alfalfa and the Persistence of the Stand

The results of two years' field trials on this problem (1952 Annual Report, page 12) strongly suggest that a stand of alfalfa will persist satisfactorily even though the first summer cutting is taken much earlier (at the pre-bud stage of growth) than is the common farm practice (at the 1/10 to full-bloom stage of growth). All summer harvests after the first were made at the 1/2-bloom stage. Taking the first cutting early provided an additional harvest and thus a better distribution of summer production. Also, by taking the first cutting early, the loss of leaves is reduced and the lodging problem of a rank-growing first crop is almost eliminated.

In the greenhouse an experiment is being conducted to provide information relative to the accumulation and utilization of carbohydrates in the roots of alfalfa harvested at different stages of growth. It is particularly important that alfalfa roots contain a good supply of reserve carbohydrates to assure winter survival.

Legume Seedling Establishment Studies

Seedling establishment studies with Ladino clover, were initiated to determine growth responses of Ladino clover in relation to the temperatures that may be expected in soil following seeding. The data taken at different temperatures include percent germination as well as rate of growth of the primary root. The rate of imbibition of water increased with temperature. Within 12 hours, at 58°F., only 10% of the seeds had swollen whereas at 95°F., 50% had swollen. Within three days, at the more favorable temperatures (58, 68, and 77°F.), the majority of the seeds had shown emergence of the root. Roots grew about 1-1/4" in 4 days. At cooler temperatures of 58°, 50° and 43°F. germination and growth were progressively slower. At higher temperatures of 95° and 104° injury occurred. The growth responses of germinating seeds will be studied in relation to extremes of temperature and moisture that occur in soil where field plantings are made.

Plant Climate Studies

In addition to temperature measurements in the microclimate (1952 Annual Report, page 12) relative humidities have received continued attention. These factors have been emphasized in relation to leaf diseases of plants, particularly of orchardgrass and alfalfa. Air temperatures and dewpoints 3 inches above the ground in alfalfa stands show that during the dry summer of 1953 the daily average maximum relative humidities usually occurring at night, were over 99% for the months of June, July and August, whereas at the standard Weather Bureau height, relative humidities at the same time averaged only 94%. During the 10 a.m. to 6 p.m. periods at 5 feet above the ground daily minimum relative humidities averaged between 40 and 50% but within the growing alfalfa they were 10 to 15% higher. During September and October 1953, when rainfall was greatly limited, relative humidities decreased 2 to 5% even though the average monthly air temperatures decreased 10 degrees.

Rate and Frequency of Potash Applications on *Dactylis glomerata*

Soil and plant analyses in this experiment have not been completed for this year but the preliminary data indicate that the results will support those of last year pointing to marked carryover of potash fertilizer in the soil from one year to another, and that most of the accumulation of potash is in the 0 - 3 inch soil layer (1952 Annual Report, page 19). It is also of interest to note that the level of exchangeable potassium in the soil receiving no potash fertilizer appears to be stabilized at about 100 pounds per 2,000,000 pounds of soil in the 0 - 3 inch soil layer. Even at this level of exchangeable potassium the orchardgrass on this soil (a residual soil derived from limestone and originally mapped as Hagerstown silt loam) is showing striking evidence of potassium deficiency symptoms.

Responses of Grasses vs Legumes to Phosphorus and Potassium Fertilization

Results the first harvest year showed no increase in yield of either alfalfa or nitrogen-fertilized orchardgrass on plots that showed very marked response to potash the previous year during the early seedling stage (1952 Annual Report, page 19). Response to phosphate was much greater in alfalfa than in nitrogen-fertilized orchardgrass. This differential response to phosphorus of established plants in the field is contrary to that obtained previously with young seedlings in the greenhouse. Moreover observations in the field last year on these same plots showed a marked response to phosphorus in the grass as well as in the legume.

Factors Affecting the Establishment of Ladino Clover in an Old Orchardgrass Sod

Investigations were continued on factors affecting reestablishment of Ladino clover in an orchardgrass sod (1952 Annual Report, page 20). Field trials showed that the depressive effect of nitrogen fertilization on seedling establishment was apparent even where the associated orchardgrass was clipped every few days. Results of greenhouse trials involving segregation of roots of the clover seedlings from those of the associated grass suggested that the poor growth of Ladino clover was owing primarily to below-ground competition rather than above-ground competition. It appears from field and greenhouse studies that on soils well fertilized with phosphorous and potassium the depressive effect of nitrogen fertilization of orchardgrass on the Ladino clover seedlings could not be attributed to increased competition for phosphorous, potassium, or moisture. Moreover, in greenhouse studies the growth of Ladino clover seedlings in association with orchardgrass was not increased by forced aeration.

Irrigation of Grasslands

This was the first harvest year of the experiment started last year in glazed clay sewer tile (1952 Annual Report, pages 21-22) to determine the effect of frequency of irrigation for different soil conditions and different plant species. Lime and fertilizer, and to a lesser extent krilium, in the subsoil greatly increased the rate of removal of water from the subsoil by alfalfa. At the same time the rate of water removal from the surface soil was markedly decreased. Therefore on treatments where water was withheld until resistance readings of gypsum blocks at a depth of 24 inches reached 40,000 ohms (i.e., approached the wilting point) the effect of lime and fertilizer in the subsoil was very marked. With additions of lime and fertilizer in the subsoil the rate of drying was fairly uniform throughout the soil profile, whereas in the controls the topsoil became extremely dry between irrigations. Yields of alfalfa under the less frequent irrigation treatments were increased about 30 percent by applying lime and fertilizer in the subsoil. Since the topsoil was liberally limed and fertilized in all cases it is believed that the higher yields obtained from lime and fertilizer in the subsoil can be attributed to differences in available water rather than available nutrients.

In orchardgrass and Kentucky bluegrass on the other hand subsoil treatments were ineffective.

It was rather surprising to find that frequent irrigation (applying water to bring the soil to field capacity when gypsum blocks at a depth of 4 inches gave readings of 3,000 ohms) gave larger increases in yield with alfalfa than with either orchardgrass or Kentucky bluegrass. These comparisons were available, however, only where the subsoil received no lime or fertilizer and where the root system of the alfalfa apparently was somewhat restricted.

It is also possible that with the highest level of irrigation there may have been enough loss of nitrogen from leaching to limit growth of the grass even though 300 pounds per acre of N were applied in 6 applications during the year.

The results this year suggest that a number of interacting factors may determine the responses obtained from different frequencies of irrigation.

REPORT OF COOPERATIVE RESEARCH

Title: PROJECT NE-10 - ADAPTATION, MANAGEMENT AND UTILIZATION OF FORAGE CROPS IN THE NORTHEAST. SUB-PROJECT 1--THE EVALUATION OF FORAGE CROPS VARIETIES AND STRAINS FOR THEIR USE AND ADAPTATION IN THE NORTHEAST.

Leader: G. H. Ahlgren, Chairman, Regional Technical Committee

Cooperators: Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia Agricultural Experiment Stations and The Pasture Research Laboratory.

This project was fully reported by H. R. Albrecht in the 1952 Annual Report, pages 23-28. Results obtained during 1953 are quite similar and accordingly are much abbreviated here.

Replicated agronomic trials of varieties and strains of alfalfa, Ladino clover, red clover, birdsfoot trefoil, orchardgrass, smooth bromegrass and timothy were seeded at seven locations in the Northeastern States in the fall of 1949 or spring of 1950. Yield and other data have been obtained for 3 seasons at each of these seven locations and at several stations for 4 seasons.

The legume varieties were tested alone and in mixture with one or more of the above grasses. Similarly, each grass variety was tested alone and with one or more of each of the above legumes. Variety performance in general has been similar whether or not the variety was grown alone or in association with another species.

Three management systems namely as hay, silage and pasture have been studied. Not all varieties were tested under all three systems of management. Generally more dry matter has been obtained from the silage system compared to pasture clippings. The varieties and

strains, however, responded similarly whether cut for silage or pasture. Thus a variety superior under a silage system of management was superior also under the pasture system.

Altogether 32 strains and varieties were evaluated. The outstanding varieties and strains are Pilgrim Ladino clover, Viking birdsfoot trefoil, Pennscott red clover, Beltsville orchardgrass and in the northern area of the Northeast, Narragansett alfalfa. Superiority is based not only on yield performance but on disease resistance, leafiness, seedling establishment, recovery following cutting and other important agronomic characters.

The second phase of this project involved seed increases of promising clones, lines, or selections of the seven species previously mentioned. Such seedlots have in most cases been increased and made available to cooperating state experiment stations and other interested groups.

The NE-10 project is being concluded with this season's trials and the data are being summarized for publication. Over-all conclusions and applications will be available after completion of the analysis of the data.

PASTURE RESEARCH AT STATE STATIONS

STORRS (CONNECTICUT)

Title: ALFALFA EXPERIMENTS

Leaders: B. A. Brown, R. A. Peters and E. J. Rubins

(a) Fertilization: In neither 1952 nor 1953 were there any indications of beneficial effects of NaCl on alfalfa receiving light applications of potash (30 pounds K_2O per acre). Analyses of the 1952 crops showed very small amounts of Na had been absorbed, regardless of the rate at which potash was added.

No effects of Mo have been noted on the yields and N contents of alfalfa on fourteen Connecticut soils, including two on which lettuce failed to grow unless either liberally limed or fertilized with a carrier of Mo.

(b) Alfalfa Varieties: The test of fourteen varieties, seeded in 1947 on land never planted to alfalfa, was discontinued after the first cutting in 1953. Some losses were due to heaving in 1951, but wilt appeared to be the chief cause of thin stands. At the final inspection (June 1953), Ranger, Buffalo, and Ladak had the best stands, while Ontario Variegated, Meeker Baltic and DuPuits were practically extinct. Several Commons, Atlantic, Cossack and Argentine were intermediate. The final yields, including the volunteer grasses, were closely correlated with the stands of alfalfa.

In a test of twenty-three strains and varieties seeded in 1950, all still had fair to good stands in 1953. Rhizoma and Viking were much less vigorous and yielded less than any of the others. Talent also had low yields, was the most susceptible to leaf-spot and, through 1953, was the only variety showing symptoms of wilt. For the three years, the other varieties, including Narragansett, Buffalo, Ranger, Common, Atlantic, Grimm and Variegated, averaged from 70 to 78 hundred pounds per acre of dry matter.

In the second harvest year of the test seeded in August 1951, eleven of the thirty varieties had markedly different ranks, based on total yields of dry matter, than in the first harvest year. These discrepancies could have been due to errors, soil heterogeneity and/or differences between varieties in time of good establishment. The eight varieties with high ranks in both years were in decreasing order: C223, DuPuits, C130, Atlantic, Common (Kansas), Williamsburg, Narragansett and C199. The eight with low yields in both years were in decreasing order: Grimm, C184, Ranger, Variegated, Talent, C180, C197 and Buffalo. (Another strain of Buffalo--F.C. 24190--averaged thirteenth among the thirty varieties.)

Title: MAINTENANCE AND IMPROVEMENT OF PASTURES

Leaders: B. A. Brown and R. A. Peters

(a) The Adaptability of Varieties and Species of Grasses and Clovers for Pastures.

Ladino Clover Fertilization: In 1953, the fourth harvest year, a Ladino clover - orchardgrass seeding receiving 60, 120, 180 or 240 pounds per acre of potash (K_2O) annually after the second cutting had respectively 40, 49, 66 and 67 percent stands of Ladino clover and produced 40, 51, 66 and 64 hundred pounds of dry matter per acre.

Where 360 pounds per acre of K_2O were applied before seeding and none since, Ladino clover had nearly disappeared in 1953 and the yield of dry matter was only 36 cwt. Even with 720 pounds of K_2O before seeding, both the prevalence of Ladino clover and the yields were decreasing rapidly in 1953. In contrast, 30 pounds of K_2O after each of the four cuttings per year had a 63 percent stand of Ladino clover and a 61 cwt. yield. Stated in another way, the decreases in yields from the first (1950) to the fourth (1953) seasons were:

For 360 pounds of K_2O before seeding	- 53 percent
For 720 pounds of K_2O before seeding	- 30 percent
For 120 pounds of K_2O before seeding and 30 pounds of K_2O after each cutting	- no decrease

Again a 180 pound application of K_2O was somewhat more effective when applied after the first or second than after the third or fourth cuttings.

The chief reason for these results appears to be the luxury consumption of potash when it is available in the soil. This is supported by the analyses of the forage:

Potash Fertilization (Lbs. K_2O per acre)	Average Percent K in Dry Matter		
	1950*	1951	1952
720 before seeding	3.2	2.9	2.6
360 before seeding	2.4	1.8	1.4
120 before seeding + 30 after each cutting	2.6	2.9	2.5

The effects of lime or soil reaction on the absorption of K have not been conclusive. In 1950, the forage from the 2 ton limestone plots analyzed practically the same as that from the 8 ton plots; in 1951, the former contained 0.3 percent more and in 1952, 0.6 percent more K.

* Third and fourth cuttings only.

For the fourth consecutive year, the highest yielding rock phosphate treatment produced less than the lowest one with superphosphate and averaged 22 percent less. The meta- and fused phosphated produced about the same as 46% superphosphate.

As in 1952, the third cutting, but not the total yield, was increased by nitrogen at 30 pounds after the second cutting. There was considerably less clover on the N plots.

Red Clover Varieties: In a test of thirteen red clover varieties, seeded in August 1951, the best stands and yields in 1953 were recorded for Kenland, Pennscott, Bayne, Ottawa and Dollard. In these respects, the poorest were Common (Oregon), Wegener, Midland and Commercial.

Birdsfoot Trefoil: As measured by grazing with yearling heifers, a birdsfoot trefoil-timothy pasture, seeded in the spring of 1951, produced only two-thirds as much pasturage as Ladino clover-grass mixtures in 1952, but about one-fourth more in 1953.

When mowed for hay on the same field as twenty-three alfalfa varieties, two varieties of trefoil averaged 77 percent as much dry matter as the alfalfas in 1951, 1952 and 1953. The Italian and the New York broadleaf varieties of trefoil yielded about the same in 1951 and 1952, but in 1953 the Italian produced 19 percent more dry matter.

Prevalence of Ladino Clover and Yields: At the termination of the ten-year cutting management experiment, there were marked differences in the stands of Ladino clover in both the orchardgrass and timothy (Kentucky bluegrass) sections of the field. From 1950 through 1953, the same favorable cutting system has been practiced on all plots. The following summary shows the importance of having Ladino clover occupy a large proportion of the area in Ladino clover-grass stands:

Stand of Ladino clover (%)	Dry Matter (Cwts. per acre) 1950	1951
15	36	--
25	42	--
35	50	--
45	50	53
55	54	61
65	58	65
75	--	68

Alfalfa for Grazing: Rhizomatous varieties of alfalfa may have special value for grazing or for leaf meal. After two years of mowing at thirty day intervals, Rhizoma had a 70 percent stand, while Buffalo under the same management had thinned to about 20 percent.

Title: USE OF HERBICIDES IN FORAGE CROP MANAGEMENT

Leaders: R. A. Peters and B. A. Brown

(a) Control of Quackgrass with Sodium Trichloroacetate (Sodium TCA) as Influenced by Rainfall: A study of the control of quackgrass (Agropyron repens) with sodium TCA was initiated in 1951 and continued to November 1953 (1952 Annual Report, page 30). Rainfall distribution was found to be the most important factor determining the amount of kill. Good control was obtained following sufficient rainfall to leach the sodium TCA in contact with the rhizomes followed by several days of scant rainfall. By dividing a given rate of chemical into two applications several weeks apart, the chances were increased of obtaining a period with a favorable rainfall pattern.

Dalapon was compared with sodium TCA in preliminary tests and was found to offer promise as an herbicide for quackgrass control which would be relatively independent of rainfall conditions, since it is absorbed by the foliage and translocated to the rhizomes.

(b) Weed Control in New Seedings of Forage by Post-Emergent Application of Herbicides: Seedings of Ladino clover alone, alfalfa alone, a Ladino clover-orchardgrass mixture, and an alfalfa-timothy mixture were made in August 1952 without a companion crop and in oats in April 1953.

In comparing the floristic composition of the chemically treated plots in the summer of 1953 (1952 Annual Report, page 31) with the composition in the late fall of 1952, some marked changes were evident. Alfalfa yields in pure stand were not markedly reduced by any of the chemicals other than 2,4-D. Ladino clover yields were significantly reduced at the .01 level by both sodium TCA alone and by sodium TCA plus 2,4-D. A linear trend occurred for each increment of chemical. Dinitro decreased the Ladino clover yield only at the highest rate of 8 pounds per acre. The initial reduction in orchardgrass stand continued to be evident at the time of harvest.

Under-seedings made in oats proved to be less subject to damage than pure seedings. When applied at the fully tillered stage, the TCA plus 2,4-D combination did not reduce stands, presumably due to the canopy effect. The Ladino clover, however, was reduced. It is considered that the TCA acting through the soil was the active factor.

C-IPC did not show herbicidal activity at any rate used; 2, 4, or 8 pounds per acre. Conditions following treatment were favorable for volatilization, which is known to reduce the effectiveness of C-IPC.

The dinitros proved to be the most promising of the chemicals used considering both weed control and effect on the forage species.

(c) Use of Chemicals in Pasture Renovation: The use of chemicals to kill sod prior to making seedings in non-tillable pastures was continued (1952 Annual Report, page 31). Fall applications gave results similar to the applications made in 1952. CMU and C-IPC at 40 and 80 pounds active ingredient per acre were effective. Sodium TCA up to 80 pounds acid equivalent were ineffective in killing the sod.

On April 18, 1953, applications of nine different herbicides were applied. The effective materials were CMU at 10, 20, and 40 pounds, sodium TCA at 20, 40, and 80 pounds, and sodium chlorate at 320 pounds per acre. C-IPC was effective only at the high rate of 80 pounds per acre. It is quite apparent that C-IPC has the greatest activity during the cool season, sodium TCA during the warm season.

Preliminary work with Dalapon indicates that it is a promising material for killing sod which is not subject to the rainfall pattern as is sodium TCA.

MAINE

Title: BREEDING AND EVALUATION OF FORAGE CROPS

Leader: L. H. Taylor

Very severe winterkilling occurred in the forage nursery at Presque Isle during the winter of 1952-1953. All legume plots were severely damaged or completely killed, and there was also some winter injury to orchardgrass, fescues, and certain other grasses. The forage nursery was re-established at Presque Isle in 1953 with plots of timothy, bromegrass, orchardgrass, alfalfa, birdsfoot trefoil, Ladino clover, and several other grasses and legumes being included. Twenty-two plant introductions and a number of selections of surviving alfalfa plants were also established at Presque Isle.

Several red clover trials were established at Presque Isle. A randomized complete block trial with 5 replications was planted to compare 26 strains developed by the NE-10 program with several check varieties. Another test with 4 replications was planted to test the performance of 30 red clover varieties and strains. Some larger plots of red clover varieties, with and without an overseeding of timothy, were also planted in the forage plots.

At Orono, a new nursery with single plots of 100 different strains of grasses and legumes was established in 1953. In addition, a randomized complete block test of 10 varieties of birdsfoot trefoil was planted, and a spaced plant nursery of individual birdsfoot trefoil plants of several varieties and polyploid populations was set out.

Title: CUTTING MANAGEMENT OF LADINO CLOVER

Leader: C. S. Brown

The effect of spring cutting date on the persistence of Ladino clover was included in a cutting management study begun in 1953. The first cuttings of Ladino clover-bromegrass, Ladino clover-timothy, and Ladino clover-orchardgrass were made on June 1, June 22, or July 15, and subsequently managed for simulated rotational pasture. The respective stages of maturity on June 1 were: orchardgrass, late head; bromegrass, heads one-fourth emerged from boot; timothy, late vegetative. The mean percent Ladino clover in a cutting made on August 15 was 73, 61, and 24 for Ladino clover-timothy and Ladino clover-bromegrass cut on June 1, June 22, and July 15, respectively; for Ladino clover-orchardgrass the respective percent Ladino clover was 50, 25 and 22.

Title: CHEMICAL WEED CONTROL IN FORAGE ESTABLISHMENT

Leader: M. F. Trevett

Studies are being continued on the use of herbicides on oats underseeded with Ladino clover or red clover. At the present time, selective dinitros are being recommended for use at the three- to six-inch stage of the oats. MCP is recommended if spraying has been delayed and a canopy of oats and weeds has developed over the legume seedlings.

Title: GRASS SILAGE PRESERVATION

Leaders: H. C. Dickey, B. E. Plummer, and C. G. M. Edgerly

During the past year grass silage was placed in conventional upright silos with sodium metabisulfite, sulfur dioxide and kylage used as preservatives and wilted grass as control. The moisture content of the four silages was about 75 percent at the time of ensiling. The grass was finely chopped and ensiled during the middle to latter part of June. The sodium metabisulfite was added at the rate of 8.2 pounds per ton, the sulfur dioxide at 5.0 pounds per ton, and the kylage at 6.7 pounds per ton.

The silage preserved with the sodium metabisulfite was very palatable, had an excellent appearance and oder, was very high in carotene, and had the least spoilage of any of the silage. The wilted silage was also very palatable, had excellent appearance, was not quite so desirable in oder as the bisulfite silage, and was medium in carotene content. The silage preserved with kylage had more spoilage, less carotene, and was the least palatable of the silages studied. At present none of the silage preserved with sulfur dioxide has been removed. These studies are preliminary and will be continued.

MARYLAND

Title: ORCHARDGRASS BREEDING

Leader: T. S. Ronningen

The polycross progeny test of selected clones (1952 Annual Report, page 35) was continued. Notes were taken on vigor, susceptibility to rust and other foliar diseases, and percentage of stand. Yields were not taken because of differences in initial stands. Progenies of several clones in each maturity group were superior to the checks used.

A new source nursery was established in 1953. Many entries were eliminated by drought.

Title: IMPROVEMENT OF RED CLOVER ADAPTED TO MARYLAND

Leaders: A. Morris Decker, Jr. and Conrad H. Liden

Activities have been concerned with further improvement of red clover lines resistant to southern anthracnose (Colletotricum trifolii). Nine isolates of the organism are being used in greenhouse inoculations of progeny from selected plants. Method of inoculation is similar to that described earlier (1950 Annual Report, pages 46-47). Plants will be rated for disease resistance, and surviving plants will be placed in the field for further selection and evaluation.

Where sufficient seed was available promising lines were planted in small replicated plots so that comparison could be made with Kenland, Pennscott and local red clover strains. These plots were planted in August 1953. Stand counts will be made but yield data will not be taken on these observation plots. Yield data will be collected on promising lines as soon as sufficient seed is available.

Title: DEVELOPMENT AND MAINTENANCE OF SUPERIOR LADINO CLOVER BREEDING MATERIALS

Leader: T. S. Ronningen

The 37 regional clones (1952 Annual Report, page 35) were established in the greenhouse in 1953 in hopes of getting polycross seed in some quantities. A limited amount of seed was obtained. Some seed has been sent to breeders for spaced-plant progeny evaluation.

The nursery of 22 replicated clones has been continued, and observational notes of important characters have been taken.

Approximately 90 clones from a three-year-old evaluation nursery at Beltsville together with eight clones from a source nursery at College Park were established in 1953 in a clonal nursery containing five replications.

Title: VARIETY AND STRAIN TESTING OF FORAGE LEGUMES AND GRASSES

Leaders: T. S. Ronningen and A. Morris Decker, Jr.

Alfalfa: Williamsburg has continued to be an outstanding variety in all tests in yields, persistence, recovery after cutting and spring vigor. Narragansett has been about as productive as Williamsburg in central and western Maryland. Buffalo and Atlantic have been somewhat lower in production and persistence in most tests.

Red Clover: Further tests with red clover strains and varieties have shown their performance to be consistent with those obtained in earlier trials, (1952 Annual Report, page 36). In tests on the Eastern Shore of Maryland during the past year Kenland red clover stands were not eliminated as they were in the 1951-52 season. However, stands and yields were inferior to those obtained with local strains. Stevens, a local strain of red clover, has been looking good in tests throughout the State.

Ladino Clover: The strain comparison test of 15 entries (1952 Annual Report, page 36) was harvested in 1953. Differences among the better entries were not significant. Ladi Otofte and an entry of Wisconsin Certified were significantly lower in production.

Annual Lespedeza: Climax, Rowen and Kobe lespedeza, in that order, were superior to Korean, a common lot of Lespedeza striata and Iowa 6 in a test near southern Delaware in 1953.

Variety tests in other species are being carried on, but the results have not modified the conclusions made in the 1952 Annual Report, pages 36-37.

Title: EVALUATION OF GRASS SPECIES AND STRAINS FOR USE WITH ALFALFA FOR HAY

Leaders: T. S. Ronningen and Nevin Brandenburg

Third-year hay yields were taken from a test including 8 bromegrass strains, 3 strains of orchardgrass, 2 varieties of tall oatgrass and commercial timothy (1952 Annual Report, page 37). In this test, which was located in the northwestern part of the State, each grass was seeded alone and in association with alfalfa.

Over the three years of the test Commercial tall oatgrass plus alfalfa produced more hay per acre than any other grass-alfalfa mixture. However, over 60 percent of the association was tall oatgrass. Other mixtures which were highly productive and averaged over 50 percent of alfalfa and over four tons per acre per year of hay were Medium Synthetic orchardgrass from the Pasture Laboratory and alfalfa, Late Synthetic orchardgrass and alfalfa, and Tualatin tall oatgrass and alfalfa. Only 13 percent of the bromegrass-alfalfa associations were smooth bromegrass, and timothy comprised less than six percent of timothy-alfalfa yields in 1953, the third harvest-year. From the standpoints of yield of alfalfa-grass mixtures, similar maturities of grass and alfalfa, and general adaptability and persistence of the grass associate, the later maturing orchardgrass seemed very promising with alfalfa for hay.

First-year yields were obtained on a test conducted at College Park. Beltsville Synthetic V was the high yielding bromegrass variety; Beltsville Synthetic VII was the least productive. Beltsville and Commercial gave the highest yields of the orchardgrass varieties. Commercial tall oatgrass outyielded the other grasses. Except for timothy there was little difference in the production of the four grass species in mixtures with alfalfa. The timothy-alfalfa mixture was the least productive.

Title: ALFALFA SEEDING EFFICIENCY STUDIES

Leaders: A. O. Kuhn, Merrill Wilcox

Seedings were made at three locations in Maryland in late March and early April to determine the importance of row seeding of alfalfa as compared to broadcast seeding. In addition 8 and 16 pound rates of seeding were compared with and without various chemical herbicides to control weeds in the initial establishment. A standard application of 100 pounds of P_2O_5 and 100 pounds of K_2O was applied at the time of seeding. Whenever the seed was banded the fertilizer was placed below the seed in bands, and whenever the seed was broadcast the fertilizer was broadcast. Plant counts made in mid-summer showed the following relationships:

Seeding Rate Per Acre	Seed and Fertilizer Applied	Ave. No. of Plants Per Sq. Ft.
16	Broadcast	18.0
16	Band	21.6
8	Broadcast	8.4
8	Band	12.7

The herbicides used included cyanamid, MCP, and CIPC and at the rates used were not effective in reducing weeds in the spring seedings.

Title: TALL FESCUE MANAGEMENT

Leaders: A. Morris Decker, Jr. and Uno Teemant

A management study on tall fescue was begun in the fall of 1952. In preparing the seedbed one tone of lime and 500 pounds of 0-12-12 was used. Three hundred pounds of a 3-12-12 were applied at seeding. A maintenance application of 700 pounds of 0-14-14 was also used. The associations used were fescue alone, fescue-Ladino clover, fescue-alfalfa and fescue-alfalfa-Ladino clover. Nitrogen was applied to all pure grass plots. The aftermath growth from each association was managed as hay, silage and pasture with three harvests made on the hay, four on the silage and five on the pasture plots. Each of these managements was cut at one, two and four inch heights. Dry matter yields were obtained and stand counts of fescue and alfalfa were made after the last harvest. Stand counts were not made for Ladino clover but each plot was rated. These counts will be repeated each fall and spring.

Dry matter yields ranged from 1.88 to 4.25 tons per acre. Highest yields were obtained for the one inch height of cutting regardless of the type of managements while the four inch height gave the lowest yield in each case. However, cutting at one inch greatly reduced the vigor of both the fescue and alfalfa which resulted in many summer grasses and weeds coming into these plots. Ladino clover percentages were generally increased at the one and two inch heights of cutting while the clover was largely eliminated at the four inch height. Little difference in yield was obtained between the three managements or between the four associations. Highest yields were obtained with fescue grown alone and nitrated.

Title: PHENOLOGICAL STUDIES IN FORAGES

Leaders: A. Morris Decker, Jr., T. S. Ronningen and H. C. S. Thom, United States Weather Bureau, Cooperating.

Soil and air temperatures were collected at various levels within a number of plots from the NE-10 Strain and Variety Test at the University of Maryland Plant Research Farm (Annual Report 1950, page 50). Large differences were found between the air temperatures at various heights. This corroborates results reported by V. G. Sprague (Annual Report 1950, page 36), and previous work at this station (Annual Reports 1951, page 42 and 1952 report, page 39). Large temperature differences were also found between measurements made inside a standard Weather Bureau shelter and those made outside by use of a shielded thermocouple. For example when average wind speeds were less than one mile per hour temperatures often differed by ten or more degrees F while a difference of 4.7 degrees F was the largest difference observed when wind speeds were between three and four miles per hour. At these speeds the air was thoroughly mixed, and small differences in temperatures were observed.

Far less winter heaving damage was observed during the 1952-53 winter season than occurred during the previous winter period. Likewise Ladino clover stands were not reduced as they were during the 1951-52 winter period.

Soil moisture was adequate for good crop growth through May and the first part of June 1953, but from then through the first half of October soil moisture was inadequate for satisfactory plant growth. Amounts of rainfall were about one-half of the long-time averages for June, July, August, and October.

Title: FERTILIZATION OF PERMANENT BLUEGRASS PASTURE

Leaders: A. Morris Decker, Jr. and Mitchell Thompson

Dry matter production was obtained for the 1953 season. Treatments used were the same as reported earlier (1952 Annual Report, page 40).

Dry matter yields in 1953 ranged from 2.05 to 4.98 tons per acre. The treatment with 400 pounds of nitrogen per acre gave a yield of 4.98 tons per acre while the 200 pound treatment produced 4.22 with a difference of only .76 tons per acre. When lime, phosphorus and potassium were applied with no nitrogen the average yield was 2.91 tons per acre while those plots receiving no lime or fertilizer produced 2.05 tons per acre.

On plots receiving high rates of nitrogen (120 pounds in three applications to 400 pounds in five applications and 200 pounds in one application) the clover was greatly reduced and in some cases entirely eliminated. Thus little advantage was obtained from the clover in these plots. The treatments receiving lime, phosphorus and potassium produced more dry matter than those treatments receiving 80, 120, and 160 pounds of nitrogen in one spring application. This was undoubtedly due to the better stand of clover which furnished nitrogen to the association in late summer. Two hundred pounds of nitrogen in one application out-yielded the lime, phosphorus and potassium treatments for the first two harvests but was considerably less for the last three.

Title: NITROGEN FERTILIZATION ON PURE GRASS AND GRASS LEGUME ASSOCIATION

Leaders: A. Morris Decker, Jr. and Robert F. Lucey

Five forage grasses are being tested for pasture production when grown alone and when grown in association with a legume. White clover was used with Kentucky bluegrass while Ladino clover was used with the remaining species. Each plot was split so that half received no nitrogen and half received 40 pounds of nitrogen in the spring and after each harvest making a total seasonal application of 160 pounds. All plots were clipped at a two-inch height except bluegrass which was cut at one inch.

These plots were established in the spring of 1952 with one ton of lime and 500 pounds of 0-12-12 being used in seedbed preparation, and 300 pounds of 3-12-12 applied at seeding. A maintenance application of 700 pounds of 0-14-14 was applied in September. Plots were clipped four times during the summer for weed control.

Yields were taken during the past season with hand separations being made to determine botanical composition. Chemical analysis for total nitrogen is now under way. The total seasonal weed free yields for the five grasses is given below.

TOTAL WEED FREE PRODUCTION TONS PER ACRE AT 12 PERCENT MOISTURE

Grasses	Grass Alone		Grass Plus Clover	
	No Nitrogen	Nitrogen	No Nitrogen	Nitrogen
Orchardgrass	.98	3.25	3.01	3.64
Tall Fescue	.81	3.12	2.45	3.44
Tall Oatgrass	.83	3.02	2.43	3.15
Kentucky Bluegrass	.61	2.15	2.52	3.03
Reed Canarygrass 1/	.25	1.09	1.52	2.04

1/ Stands were thin because of poor seed germination. This accounts, in part, for the low yields obtained for Reed Canarygrass.

Nitrogen application on the grass alone plots greatly increased yields. However, yields were not substantially better when nitrogen was applied to the grass legume associations. On these particular plots there appeared to be a depressing effect on clover stands beginning with the second harvest. Small increases in yield were observed on these plots. This increase in yield was the result of an increase in the grass component.

Title: GRASS AND LEGUME COMBINATIONS FOR BEEF PRODUCTION

Leaders: T. S. Ronningen and A. Morris Decker, Jr.

The grazing paddocks containing orchardgrass-Ladino clover, tall fescue-Ladino clover, or Kentucky bluegrass-white clover were grazed by yearling Hereford steers again in 1953, the fourth grazing year (1952 Annual Report, page 40). Beef gains per acre were greatest on the orchardgrass-Ladino clover combination with Kentucky bluegrass-white clover and tall fescue-Ladino clover following in that order. During the summer the steers were regrouped, and their gains were compared on common pearl millet, Korean lespedeza, and sweet Sudan grass. Beef gains per acre were in the same order with the greatest gains being from common pearl millet.

The grazing trials will be continued in the same manner in 1954.

Title: CONTROL OF WEEDS IN LEGUMES

Leaders: A. O. Kuhn and Merrill Wilcox

A mixture of alfalfa, Ladino clover, and smooth bromegrass was seeded in August 1952 on a well-drained Chester loam in central Maryland. Several herbicides were applied as post-emergence spray at three dates in the winter. Ammonium DNOSBP at 1, 2, and 4 pounds per acre gave temporary control of chickweed without damage to the desirable plants. CIPC applied alone at rates ranging from 1 to 8 pounds per acre controlled chickweed but tended to eliminate the grass. A combination of 2 pounds of CIPC and 1/4 pound MCP, applied in late October was the most effective weed control treatment tested as it controlled chickweed, winter cress and field pepper grass without damage to alfalfa.

MASSACHUSETTS

Title: SOURCES OF FERTILIZER PHOSPHORUS FOR FORAGE CROPS: SUPERPHOSPHATE VS GROUND RAW ROCK PHOSPHATE

Leaders: Mack Drake, J. E. Steckel, Jean Pellissier, and W. G. Colby

This project was described in the 1951 Annual Report, pages 45-49. Results from both field and laboratory experiments since the 1951 report have contributed greatly to a better understanding of the fundamental principles of soil-phosphorus and plant-phosphorus relationships.

We believe that the availability of soil phosphorus to growing plants is largely controlled by the presence of certain organic compounds, principally organic acids produced in the breakdown of soil organic matter. The availability of soil phosphorus to individual plant species is further influenced by the cation exchange capacity of the roots of that species.

Our data show that certain organic anions, such as the citrate anion, act as chelating agents for free iron and aluminium in the soil and also combined iron and aluminium as iron and aluminium phosphates. We believe that the presence of relatively large quantities of chelating organic substances in the root environment of perennial forage crops explains why these crops are able to utilize phosphate fertilizers so efficiently. Orchardgrass in three years' harvests for example extracted 180 percent of the phosphorus from 50 pounds of applied P_2O_5, 110 percent from 100 pounds of applied P_2O_5 and 58 percent from 200 pounds of applied P_2O_5.

We find that the availability of phosphorus from raw rock phosphate depends upon the presence of a chelating substance for calcium. For example we find that Ethylenediamine Tetra Acetic acid (EDTA)

is a very effective agent for solubilizing the phosphorus in raw rock phosphate. We also find that plants with high cation exchange capacity roots can extract phosphorus more effectively from ground raw rock phosphate than plants with roots of low exchange capacity. This explains why alfalfa and the clovers for example can utilize ground raw rock phosphate so much more effectively than a grass such as timothy.

Experimental evidence also shows that new seedlings cannot obtain adequate phosphorus from the relatively unavailable forms as iron, aluminium, and rock phosphates. In contrast, plants with established root systems utilize relatively unavailable forms of phosphate chiefly as a result of chelation by organic root substances (both decomposing and nondecomposing). We believe the absence of established root systems to be the reason for the poor utilization of phosphorus from ground raw rock as compared to super when rapid growing annuals such as potatoes, vegetables, annual grasses or cereals are used as the test crop. Hence if raw rock phosphate were to be used, we would suggest the use of some super phosphate to supply some readily available phosphorous to facilitate seedling establishment. Plants with high exchange roots such as alfalfa, red clover and Ladino clover are highly effective in utilizing phosphorus from rock phosphate but only after these plants have become established and have developed a root system.

In field plot work with forage crops, rock phosphate alone often produces poorer results than superphosphate or the super-rock combination. We believe that a poor initial stand is largely responsible. The seedlings simply cannot obtain their phosphorus requirements from low availability materials, so death and stunted plants reduce the stand. Perennial plants especially alfalfa, and Ladino clover, which can utilize rock phosphate effectively, once their root systems are established, feed effectively on the rock phosphate and also on other forms of soil phosphate of low availability. Rock phosphate should not be used alone to establish a new legume-grass seeding, and rock phosphate should not be used for rapid growing annual crops.

The following are yield results for rock-super studies on forage mixture, grown on Hudson silt loam near Williamstown, Massachusetts. A mixture of smooth bromegrass, timothy, orchardgrass, Ladino clover, alsike clover, and alfalfa was used.

TWO YEAR DRY MATTER FORAGE YIELD FROM PLOTS VARIOUSLY TREATED WITH PHOSPHATE FERTILIZERS. Experiment located near Williamstown, Massachusetts.

Treatment	Yield (lbs. per Acre)	Treatment	Yield (lbs. per Acre)
No P	8100	500 super (20%) + 1000 rock	13600
100 sulfur	9800	500 super 20%	11400
1000 R+ sulfur	10300	1000 super 20%	11500
2000 R+ sulfur	10200	2000 super 20%	14100

Here the yield difference in favor of super results largely from a better forage stand. Low stand population is expected to continue to hold rock yields at a level below those with super. The rock-super combination should be carefully considered. P content of forage from rock and super plots was comparable. The soil pH was 6.5.

FOUR YEAR DRY MATTER FORAGE YIELDS FROM PLOTS VARIOUSLY TREATED WITH PHOSPHATE FERTILIZERS. Experiment located on a Loessial Soil near Amherst, Massachusetts.

Treatment	Timothy lbs./acre	P_2O_5	Alfalfa lbs./acre	P_2O_5	Ladino Brome lbs./acre	P_2O_5
2000 rock 34% P_2O_5	31009	116	25473	111	17429	101
1000 super 20% P_2O_5	31735	112	25851	115	17131	103
2000 super 20% P_2O_5	32559	126	26576	121	17658	113
500 super + 1000 rock	33725	127	26950	116	17621	110

In each field experiment all P was applied before seeding. Yield differences here are small. The combination of rock and super has produced forage equal in dry matter and P content to that from 2000 pounds superphosphate.

These field experiments plus basic information from the laboratory and greenhouse show that perennial forage crops can obtain part of their phosphate requirement from rock phosphate. High analysis rock phosphate can if necessary become an important source of phosphorus for forage crops.

NEW HAMPSHIRE

Title: VARIETY TESTING OF ALFALFA, SMOOTH BROMEGRASS, LADINO CLOVER AND RED CLOVER

Leaders: P. T. Bleed, G. M. Dunn and L. J. Higgins

The third year of yield data have been obtained on six alfalfa varieties (1952 Annual Report, page 44). Narragansett has been the highest in yield for three consecutive years. In 1953, this variety produced 4,196 pounds of air-dry forage per acre compared to the next best variety, Ontario, which produced 3,683 pounds. Stand loss has occurred with Ranger, apparently due to winter killing. The varieties Ontario and Atlantic have held up well.

A yield trial of ten bromegrass varieties was established in 1952 at two locations, one in northern and one in southern New Hampshire. A split plot design was used, bromegrass alone and with Ladino clover. In 1952, a test of five New York synthetics was established in Durham.

Good stands were obtained for both the bromegrass and Ladino clover at the northern location. Significantly higher yields, in some cases twice as much forage, were obtained with the mixture as compared to bromegrass alone with average fertilizer applications. Achenbach, Fischer and Lyon varieties of bromegrass were somewhat higher in yield than Lincoln, Southern Commercial, Elsberry and Lancaster. The northern varieties, Parkland and Canadian Commercial, as well as Oklahoma synthetic, were significantly lower in yield than the other seven southern varieties. The variety X association interaction was not significant.

Fair to poor stands were obtained in this test at Durham, especially for the Ladino clover in the mixture. After elimination of weeds and grass from yield calculations, bromegrass alone yielded more than bromegrass plus Ladino clover at Durham. This was partially due to the poor stand of Ladino clover present, and the severe drought at this location in 1953. Fischer, Lyon and Elsberry were the leading southern varieties of bromegrass while Parkland and Canadian Commercial were lowest in yield. Stand and yield were quite variable for the New York synthetics seeded in 1952.

Yields were obtained for the third year (1952 Annual Report, page 43) for the Ladino clover strain test at Durham. Yields of all strains were low because of prolonged drought in 1953. No significant difference was obtained between certified Oregon, Commercial Ladino clover and PC23608.

Another Ladino clover test of eight strains was established in northern and southern New Hampshire in 1953.

Replicated plots of N. H. Red Clover, Dollard, Kenland, New Brunswick and Pennscott varieties were seeded during the summer of 1953 for yield trials in 1954 and the following years. These plots showed good stands and went into winter in good condition.

Title: BREEDING OF SMOOTH BROMEGRASS, LADINO AND RED CLOVER

Leaders: G. M. Dunn and L. J. Higgins

Approximately 3,000 spaced bromegrass plants have been established in a source nursery during 1952 and 1953. A polycross nursery of selected clones from the 1952 source nursery was established in 1953. Two hundred selected clones differing in degree of field resistance to brown leafspot will be inoculated with the disease this winter. Approximately 4,000 seedling plants, the open-pollinated progeny of these clones, also will be tested for resistance to brown leaf spot.

Source nurseries of about 3,500 white clover plants were established with fair success during 1953. Approximately 80 strains, ranging from white to the polyploid Vermont Ladino clover, will be studied primarily for persistence and for correlations of morphological characters with persistence.

The following designs also were established to obtain information on competition between species in a breeding nursery:

a) Alternate rows of spaced Ladino clover and smooth bromegrass.
b) Spaced Ladino clover plants overseeded with bromegrass.
c) Spaced bromegrass plants overseeded with Ladino clover.
d) Spaced Ladino clover plants enclosed by alternate rows of bromegrass and timothy.
e) Spaced bromegrass plants enclosed by alternate rows of Ladino and red clover.

A small amount of N. H. red clover breeder seed was obtained in the greenhouse from one, two, and three-year old isolated plants. It is planned to make an increase planting with this seed.

Title: THE INFLUENCE OF SOIL TYPE ON THE PERSISTENCE OF PERENNIAL LEGUMES

Leaders: L. T. Kardos, P. T. Blood, and R. L. Donahue

On the Worthington loam in extreme northern New Hampshire all the legume stands (seeded in August 1950) deteriorated strongly after the second cutting in 1952 as shown by the percentages of legume in the forage of the second cuttings in 1952 and in 1953.

	Percent Legume in Second Cutting	
	1952	1953
Ladino clover	38	<2
Red clover	58	<2
Alfalfa	46	3
Birdsfoot trefoil	54	17

In a 1951 seeding on the Stratham gravelly loam, a droughty soil in southern New Hampshire, a severe summer drought again imposed severe restrictions on the yield of Ladino clover. As a result, the average yields of the red clover, alfalfa and birdsfoot trefoil at the second cutting were more than double that of the Ladino clover. The second growth of the trefoil was not so good as that of the red clover and alfalfa.

Second Cutting Legume Yields
(lb./A. Air-Dried)
1953

Ladino clover	116
Birdsfoot trefoil	269
Red clover	680
Alfalfa	740

Title: THE FERTILITY NEEDS OF LADINO CLOVER

Leaders: L. T. Kardos, P. T. Blood, and R. L. Donahue

Both experiments, at Northwood on Paxton loam and at Colebrook on Worthington loam, continued to show the same potash and lime influence on yield of Ladino clover that was shown in 1952 (1952 Annual Report, page 45). However, the stands of Ladino clover deteriorated strongly during the winter of 1952-53 to the extent that the best plots at Colebrook (50 lbs. K_2O in the spring and 50 lbs. K_2O after the first cutting, and two tons of lime at seeding) dropped from an average of 42.9% Ladino clover in the forage of the second cutting to a value of 14%. At the Northwood location the percent of Ladino clover in the forage of the second cutting of the same treatment dropped from 20% to less than 1%.

At both locations the grasses (predominantly timothy and bluegrass) continued to reflect the potash and lime treatments by their growth responses.

Title: THE EFFECT OF HEAVY FERTILIZATION OF THE SOIL ON THE TRACE MINERAL CONTENT OF FORAGE AND THE EFFECTS OF FEEDING SUCH FORAGE TO DAIRY CATTLE

Leaders: H. A. Keener, F. E. Allen, C. H. Boynton, K. S. Morrow and G. P. Percival with cooperation of K. C. Beeson and E. J. Thacker, U. S. Plant, Soil, and Nutrition Laboratory, Ithaca, New York.

The trace mineral content of the forage in 1953 was in general lower in copper and higher in cobalt than in 1952. Timothy and bromegrass were low in iron, copper, and cobalt while Ladino clover was low in copper and fairly low in cobalt. Some samples of Ladino clover were very low in manganese.

Cattle which have been fed the low trace mineral forage along with a low mineral concentrate mixture are exhibiting symptoms of iron and copper deficiency and also exhibited cobalt deficiency symptoms until this element was added to the diet. This past fall and winter a majority of the calves born to the mineral deficient animals have had large goitres. This has been a rather surprising development because the land on which the forage was grown is only 28 miles from the Atlantic Ocean. Although it appears that the trace mineral deficiencies have not affected reproduction adversely, it is of interest to note that the animals fed Ladino clover-bromegrass hay have required over twice as many services per conception as those fed timothy hay. The reason for this difference is not yet known.

Title: MAXIMUM USE OF SILAGE IN FEEDING DAIRY CATTLE

Leaders: H. A. Keener and N. F. Colovos

A study was started last spring to study the need for supplementing grass silage with corn silage and/or hay in feeding dairy cattle. The experimental animals consisted of 12 Guernsey and 12 Holstein heifers. They were started on experiment at a few days of age, and were fed 25 pounds milk replacement, 200 pounds dry calf starter, and 300 pounds dairy ration. Beginning at the start of the experiment one-fourth of the animals in each breed were fed grass silage as the only roughage, another fourth received grass silage plus limited hay, another fourth received grass silage plus corn silage, and the final fourth recieved grass silage plus both corn silage and limited hay. After concentrate feeding is discontinued, the various roughage combinations will be the only feeds fed until the animals have milked at least two lactations.

In addition to bringing out maximum differences between the various roughage combinations, this experiment will give information on the value of silage in feeding young calves and indicate rates of growth and milk production which can be supported on high quality roughage when fed without any concentrates.

Title: EFFECT OF VARIOUS PRESERVATIVES ON THE CAROTENE CONTENT OF GRASS AND LEGUME SILAGES

Leaders: G. P. Percival and D. Josselyn

Timothy, red clover and Ladino clover samples were stored at a nearby farm in a silo filled with sulfur dioxide treated silage. The results, based on the actual amount of carotene put into the silo and the actual amount removed, showed that the timothy lost the least amount of carotene while the red clover and Ladino clover loss of carotene was considerable.

Sodium metabisulfite was found to be very effective in preserving the carotene content of forages when compared with untreated silage. It was effective for both timothy and alfalfa but not so good for red clover; however, the untreated red clover showed considerably more loss than did the untreated timothy and alfalfa.

This year 55 gallon oil drums, painted and lined with sisal-kraft paper, were used to compare untreated silage with silages treated with dried stabilized molasses, sodium metabisulfite and calcium formate. The contents were weighted on top with sand to try to duplicate silage conditions.

NEW JERSEY

Title: BREEDING PRODUCTIVE, WILT-RESISTANT ALFALFA VARIETIES ADAPTED TO HUMID EASTERN CONDITIONS

Leader: W. R. Battle

Activities have been concerned with attempts to increase wilt-resistance through a program of artificial inoculation and selection, increase and distribution of seed of the Atlantic variety, development of breeding methods, and participation in the regional and national programs for evaluation of superior new strains and varieties of alfalfa. Plantings presently in existence include the following:

1940 Atlantic Breeder Seed Field: One-half acre in area. Parental stock of the Atlantic variety, seeded in rows, one foot apart. Harvested for seed annually since 1941. Nine seed lots representing successive harvests from this field, plus 6 other lots representing various stages in development of the variety, were subjected to a controlled test for wilt resistance. No significant changes in reaction were ascribed to advance in generation or growth outside the primary area of adaptation. A significant change resulted from the action of natural selection on the aging stand, the seed from surviving plants carrying much more resistance to the disease.

1948 Uniform Alfalfa Nursery: Twenty-one entries, 4 replications, plots 5 x 16 feet, randomized block design. Harvested for hay 3 times annually. A 5-year summary of yield data showed that the Atlantic variety, and polycross progenies of clones C22, C53, C126, and C235, had significantly outyielded all other check varieties including Buffalo, Grimm, Kansas Common, Ladak, Narragansett and Ranger. Good stands have been maintained into the sixth year after planting, with Ladak being the only variety showing marked thinning out.

1951 Wilt Epidemic Nursery: Originally contained 14,000 spaced plants representing progeny of 139 wilt resistant selections from 1948 Wilt Epidemic Nursery. Each plant was inoculated with Bacterial Wilt disease in 1951. All entries trace directly back to Atlantic parental strains. Survival counts showed that the nursery as a whole averaged more than twice the survival of the Atlantic checks, and certain of the strains were almost completely resistant. Seed was harvested from 37 of the best strains this year, and will be used for making up experimental synthetic varieties.

1951 Atlantic Breeder Seed Field: Five acres in area, plants spaced 28 inches by 28 inches apart, overseeded with timothy. Harvested for seed in 1952 and 1953. Spraying the plants with Di-Nitro several days before harvest has permitted direct combining of the standing seed crop during the past two years with very little loss of seed, and no injury to the plants. Increased seed yields resulting from establishment of this field have solved breeder seed problems with Atlantic, and about two and one-half million pounds of certified seed of the variety are now being produced annually.

1952 Seed Source Test: Includes seed lots of Atlantic, Buffalo and Ranger alfalfa representing breeder, foundation, registered and certified generations from several states and various ages of stand. Four replications each of 110 entries, seeded broadcast in plots measuring 6 x 20 feet. Data recorded on yield, stand, vigor, recovery after harvest. No clear cut differences between seed lots within varieties, during the first year.

1953 Seedling Vigor Nursery: Three hundred thirty-three wilt resistant alfalfa selections (from 1950 Wilt Epidemic Nursery) and 11 check varieties seeded in 5 foot rows, cubic lattice design, 3 replications. Seedling vigor measurements were recorded six weeks after emergence, and yield was recorded at seven weeks and fifteen weeks after emergence. Significant differences between strains were found for seedling vigor and for yield at each harvest. Vigor was positively correlated with yield, substantiating earlier findings at this station that seedling vigor may be used as a selection criterion for yielding ability.

1953 Uniform Alfalfa Variety Test: Fifteen varieties, 6 x 20 foot broadcast plots, 6 replications, randomized block design. Seeded in fall. Dry weather retarded emergence, resulting in thin stands.

1953 Alfalfa Quality Test: Thirty-six alfalfa clones selected for differences in yield, leafiness and color were propagated vegetatively and established in a replicated greenhouse planting. Studies will be made of morphological characters and chemical composition of the plants, and the relationships between the characters. The planting will be transferred to the field next Spring for continuance of the study under field conditions.

Title: EFFECT OF TIME OF FERTILIZING ALFALFA

Leaders: J. L. Gerwig and G. H. Ahlgren

This study was started in 1952 (1952 Annual Report, page 52). One season's yield data have been analyzed and only those treatments following the first cutting showed a significantly higher annual yield than the check plots.

No differences in persistence or botanical composition were found due to treatment this first season. Chemical analysis has not been completed on nutrient return. Insect control on all plots was very effective and will be continued each season until the project is terminated at the end of 5 years.

Title: PASTURE RENOVATION STUDIES

Leader: M. A. Sprague

Previously established experiments (1952 Annual Report, page 50) were continued, observed and harvested and several new experiments

were inaugurated during 1953 in the testing and developing of principles of seedbed preparation on unplowable pastures.

The initial seasons 1949-52 of normal rainfall have given very encouraging results in New Jersey with the use of TCA as an aid to renovation. The dry season of 1953 presented new problems and different results, though not opposite nor discouraging. Summer sprayed TCA stayed in the soil until late fall rains came and accordingly, August seedings were unsuccessful.

Chemicals of long duration in the soil, such as CMU and PDU, show promise for use in fall to be followed by spring seeding. Dalapon, a systemic grass killer, brought about 100% kill with both July and October applications at only 5# per acre. Residual effects of Dalapon on new seedings appear to be no problem at low rates.

Versatility in adaptation will make the procedure attractive on farms. Fall seeded grains on a dead and disked sod carried a mulch throughout the winter. Late winter sown clover established itself well in 1952. The same procedure on a plowed seedbed gave a poor catch. Both yielded 9000 lbs. dry forage in 1953.

A 10 acre trial at Annandale, New Jersey yielded in 1953 a total of 5472, 5375 and 5969 pounds dry forage per acre from the chemically renovated, disk renovated and plowed areas respectively. These were all more than 4 times the production from untreated areas (1323).

At New Brunswick, disk renovated plots yielded 5024 pounds dry forage in 1953 and chemically renovated plots yielded 5032 pounds. The bluegrass content of the former was 12% in September and of the latter only 4%. These and other data indicate renovations in which herbicides have been used will most likely last longer.

Title: A SURVEY OF THE QUALITY OF HAY MADE ON NEW JERSEY FARMS

Leader: R. C. Wakefield

Over 1830 hay samples obtained from a representative segment of New Jersey farms over a 4 year period graded as follows: U. S. No. 1, 19.2 percent; U. S. No. 2, 43.2 percent; U. S. No. 3, 19.7 percent; sample grade 16.6 percent and unclassified, 1.3 percent. Data were obtained from each farm on hay production practices and a physical and chemical evaluation of the hay samples made.

Cutting hay early and curing rapidly and adequately to retain a maximum amount of green color and leafiness resulted in higher grades as determined by the U. S. Hay Standards. Production of hay high in legume content, low in foreign material and of good soundness contributed greatly to quality.

A study of the nutritive value of the hay as measured by chemical feed analyses revealed that the crude protein, ether extract and ash content of hay increased with legume content. This relationship appeared to hold for the various grades with an advantage often directed toward the higher grades. The crude fiber and nitrogen-free extract content of hay decreased with increasing legume content. The higher grades of hay exhibited a higher average nitrogen-free extract content and a lower average crude fiber content.

Title: EFFECT OF PLANT FOOD COMBINATION OF ALFALFA

Leaders: J. L. Gerwig, and G. H. Ahlgren

This study was started in 1952 (1952 Annual Report, page 52). One season's yield data have been analyzed and in general those treatments containing high potash showed a significantly higher annual yield than the check plots or those receiving only superphosphate. One treatment, 25-100-200, was significantly higher than the check plots at each of the three cuttings.

The various treatments, as yet, have had no effect on persistence or botanical composition. Chemical analysis has not been completed on nutrient return. Insect control was very effective and will be continued each season until project is completed. This study will continue for 5 years and more conclusive results are expected as work progresses.

Title: A STUDY OF THE MAXIMUM RESPONSE AND NUTRITIVE VALUE OF GRASSES TO NITROGEN AND POTASH TREATMENTS

Leaders: Carroll H. Ramage, C. Eby, R. E. Mather, B. R. Poulton, E. R. Purvis.

Forages used in the experiment are orchardgrass, reed canarygrass, alfalfa-bromegrass mixture, and alfalfa-orchardgrass mixture. The grass plots were fertilized with 100 pounds per acre of potash and of phosphorus pentoxide, and the amounts of nitrogen applied were 50, 100, 200, and 400 pounds per acre. The legume-grass mixtures received a basic 150 pounds of P_2O_5 per acre, two levels of potash 150 and 300 pounds, and three levels of nitrogen 0, 75, and 150 pounds.

Yield - 3 Cuttings

Forage	Treatment			
	50# N lbs./acre	100# N lbs./acre	200# N lbs./acre	400# N lbs./acre
Orchardgrass	6420	6860	7960	9140
Reed Canarygrass	6200	6720	7810	9220

Forage	Treatment: 1500# per acre of 0-10-10	0-10-20	5-10-10	5-10-20	10-10-10	10-10-20
Alfalfa-orchardgrass	5990	6020	5680	5420	5960	5940
Alfalfa-bromegrass	6160	6690	7290	7190	6710	7180

Chemical analyses of first cutting samples show increases in protein in the grasses from 11% to 20% with increasing amounts of nitrogen applied. The legume-grass mixture samples all analyzed about 18% protein, regardless of fertilizer treatment.

The experiment will be continued for a total of three years. Yields, proximate analyses, plant population changes, and soil nutrient status are being determined. The feeding value of the forage produced will be estimated from the chemical composition.

Title: EFFECT OF TIME OF FERTILIZING BIRDSFOOT TREFOIL

Leaders: J. L. Gerwig and G. H. Ahlgren

This study was started in 1952 (1952 Annual Report, page 53). One season's yield data have been analyzed and no treatment gave a significantly higher annual yield than the check plot. However, those plots receiving treatment following the first cutting gave a significantly higher yield at the second cutting than the check plots.

No difference in persistence or botanical composition was found due to treatments. Chemical analysis has not been completed on nutrient return. Insect control on all plots was very effective and will be continued each season until the termination of the project.

Title: TIME, METHOD AND STRAIN OF INOCULANT STUDIES WITH BIRDSFOOT TREFOIL

Leaders: M. A. Sprague and C. Eby

The greatest handicap to wider use of birdsfoot trefoil in New Jersey is unreliable establishment. An inoculant study was undertaken at the Dairy Research Farm at Beemerville, New Jersey to determine whether improper or inadequate inoculation may be partial cause of so many seeding failures.

The seeding was made on August 11, 1953 on a well prepared seedbed following oats and peas and on a field where no trefoil has been known to have been grown before. The experiment included 2 varieties, Granger and Empire; seed scarification and no scarification, 4 commercial strains of Rhizobia as inoculants plus no inoculation; 3

sticker solutions including water, 2% syrup and a non-carbohydrate sticker (wetting agent 60-L); the inoculants applied with and without ground limestone. Half of each plot will be re-inoculated with surface application during the spring of 1954.

The dry fall season masked differences in establishment during the fall of 1953. Good establishment occurred during late fall.

Title: EFFECT OF PLANT FOOD COMBINATIONS ON BIRDSFOOT TREFOIL

Leaders: J. L. Gerwig and G. H. Ahlgren

This study was started in 1952 (1952 Annual Report, page 53). One season's yield data have been analyzed and those treatments that contained heavy nitrogen application showed significant differences. Those treatments were: 100-100-200 and 200-100-200. This difference was found only in the first cutting and neither the second nor the third cutting showed any significant yield increase in any treatment over the check plots.

Treatments, as yet, have not affected persistence and botanical composition. Chemical analysis has not been completed on nutrient return. Insect control was very effective and will be continued each season until project is completed. This experiment will be continued for 5 years and it is expected that more conclusive results will be found in the future.

Title: THE "ZERO PASTURE" OR CHOPPED GREEN FORAGE PROGRAM FOR DAIRY CATTLE IN NEW JERSEY

Leaders: B. Poulton, R. Mather, C. Eby, G. Luke and J. Brockett

The object of the experiment was to determine the economic feasibility of feeding field chopped roughage in the manger. Records were kept of labor requirements in harvesting with a direct cut forage harvester, hauling and feeding, acre yield; amount consumed and variation in daily milk production were compared to a herd of similar bred cows on pasture.

Partial results indicated tha manger fed cows consumed an average of 92 pounds green weight or 19 pounds dry matter per cow per day for three months, June, July and August.

The 50 Holstein milk cows in the test consumed the roughage harvested from 8-1/2 acres of peas and oats, 38 acres of second cutting hay crop and 3-1/2 acres of sorghum and soybeans. Average daily labor requirements for harvesting and hauling 2 loads per day a distance of 3 miles 2.76 man hours and to feed the same amount was 1.5 man hours.

Partial results indicated less variation in milk production from day to day with a smaller decrease in production from June 1 to September 30 than the corresponding group on pasture.

Title: UTILIZATION OF PASTURE IN THE PRODUCTION OF BEEF

Leaders: A. G. Strecker, G. W. Vander Noot and M. A. Sprague

During 1953, heavy steers were used for pasture studies at the New Jersey Experiment Station for the second year. On April 10, 1953, 14 Hereford feeder steers averaging 978 pounds were put on 21 acres of 2, 3, and 4 year old stands of orchardgrass, bromegrass and Ladino clover pasture. They remained on pasture until August 15, a total of 127 days. During this period, the steers made an average daily gain of 1.75 pounds per animal and total for the short season of 222 pounds. This amounted to 151 pounds per acre, 46 pounds less than during 170 days in 1952 (1952 Annual Report, page 54). The market and drought conditions which prevailed determined the choice to sell the steers on August 15, 1953 rather than hold them for the entire pasture season. In addition to the beef, 1.7 tons of hay per acre was harvested from these pastures on June 12. This is approximately the same production obtained during the previous 4 years of this study.

Title: A STUDY DESIGNED TO MEASURE THE MILK PRODUCING POTENTIALS OF GRASS-LEGUME SILAGE

Leaders: Bruce R. Poulton, John W. Bartlett, Robert E. Mather, and George H. Bonnington Jr.

A three lactation study of the amount of milk which can be produced by cows fed grass-legume silage ad libidum as the principle roughage with hay intakes regulated at 5 pounds of alfalfa-bromegrass hay daily is in progress. Grain is fed at three levels based on the daily production of 4% fat corrected milk. The first group of cows receive no grain, the second group of cows receive 1 pound of grain for each 3 pounds of FCM and the last group receive 1 pound of grain for each 6 pounds of FCM.

Twenty-four dairy cows representing two breeds are being used in this study with 8 cows designated for each grain feeding group. Insofar as possible, the same 24 cows will be used for the entire three year period. One half of these cows will remain on the same level of grain feeding through all three lactations whereas the other half will be rotated on the three levels for the three lactations in a latin square design. One lactation has been completed on this experiment and the second lactation period is in progress.

Title: HORSE PASTURE RESEARCH INVESTIGATIONS

Leader: Blair M. Ritter

The investigation of pastures specifically for horses is a new study started this year in New Jersey. Preliminary investigations have been undertaken preparatory to organizing an Experiment Station Project. A survey of the horse farms in the state is being conducted. Farms engaged in horse breeding are being visited to learn the pasture problems existing on horse farms. Preliminary observations indicate that investigations into management and mineral content of horse pastures offer opportunity for improvement.

Title: CONTINUED STUDIES OF CHICKWEED CONTROL IN ALFALFA

Leader: Richard J. Aldrich

It is clear that effective control with DNOSBP is associated with time of treatment whereas date of treatment has relatively little effect with the carbamates tested. Single treatments of DNOSBP have never controlled chickweed when applied after the chickweed is heavily matted; control of matted chickweed has been obtained with repeat treatments. The 1953 results suggest that DNOSBP rates as low as 1/2 pound per acre may control chickweed if it is treated while in the seedling stage. There would not appear to be pronounced differences in control obtained with the DNOSBP formulations; control with the amine salt was slightly, but measurably, less than with the other formulations.

IPC appears to be satisfactory for control although more chemical is required than with Chloro-IPC.

CORNELL UNIVERSITY (NEW YORK)

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS WITH THE FORAGE PLANTS OF NEW YORK (B. J. PLANT BREEDING PROJECT 76)

Leaders: R. P. Murphy, C. C. Lowe, S. S. Atwood and D. L. Smith

This report covers the fiscal year 1952-53 (1952 Annual Report, page 54). The breeding and cytogenetic studies are described here separately for each species.

A. Alfalfa

1946, 1947, 1948, 1949, 1950 Uniform Observational Nurseries: Notes were taken on several characteristics. From this information the materials which are superior are selected for further use.

1949, 1950 Clonal Nurseries: These were studied again in 1952 and the best clones will be selected and transferred to a maintenance nursery.

1951, 1952 Maintenance Nursery: All clones of value to the research program are maintained in rows of ten cuttings for each.

1949 Single Cross Nurseries: These progenies were studied again in 1952 and noted especially for persistence and vigor. The selections previously made have continued to be superior in vigor and disease resistance.

Twelve of these single crosses have been selected for use in the breeding program, either as varieties directly or as parents of double-cross varieties. Appreciable quantities of seed of the first-advanced-generation were produced in cages (with honey bees) in 1952.

1949 Inbred Progeny Nursery: This nursery was studied again and a few desirable plants selected.

1950 Single Cross and Inbred Nursery: Some of the plants from crosses between creeping-rooted clones from Saskatchewan and clones adapted in New York distinctly showed the creeping-rooted character. Twenty-six of these were selected for intercrossing and also back-crossing to the New York clones for the second cycle in the breeding program to develop a creeping-rooted alfalfa adapted in this State.

1951, 1952 Seedling Source Nurseries: These seedlings are being studied in order to find new superior plants and to observe the variation in both natural tetraploid and diploid populations.

Disease Resistance Studies: Selected plants from the studies on bacterial wilt resistance and common leaf spot resistance were noted for reaction again in 1952. They were also noted for other desirable characteristics. A new series of seedlings selected for bacterial wilt resistance were transplanted to the field in 1952.

Leaf Hopper Reaction Studies: The study of the reaction of a number of clones and their progenies to the potato leaf hopper indicates that heritable differences exist among clones. A pubescent plant character was studied and was found to be associated with resistance.

Carotene Studies: The study of the variation among a number of clones and their progeny for beta-carotene content has indicated considerable heritability for this character.

B. Red Clover

No seed was obtained in 1952 from the 3-year old plants but this effort will be continued.

C. Ladino Clover

1951 Clonal and Seedling Nursery: The clones and their restricted polycross progenies which are the parents of the experimental synthetic, F.C. 23,608, were observed for persistence.

D. Zig-Zag Clover

The selected materials are being maintained although some have been lost. Hereafter, these materials will be used only in the clover interspecific hybridization program.

E. Alfalfa, Clover, and Grass Introduction Nursery

A number of lots of seed were planted in 1950 and 1951. Several of the alfalfas and a few bromegrasses will be selected and studied in more detail. As would be expected, many of the lots were unadapted and have not survived or will be discarded. One collection of alfalfa from Saudi Arabia with heavy pubescence has been included in the study on leaf hopper resistance.

F. Clover and Birdsfoot Trefoil Interspecific Hybridization

The crosses between T. ambiguum and T. hybridum and between T. nigrescens and T. repens have been successful. However, all F_1 plants of the first cross have been sterile to date. The F_1 plants from the latter cross have been at least partially fertile and F_2 and backcross populations have been obtained for genetic studies.

G. Smooth Bromegrass

A new source nursery of seedling plants was established in 1952 and some progenies appear to be very promising in this second cycle of selection.

Title: THE EVALUATION OF FORAGE CROPS VARIETIES AND STRAINS FOR THEIR USE AND ADAPTATION IN THE NORTHEAST. SUBPROJECT I: EVALUATION OF FORAGE CROPS VARIETIES AND BREEDING MATERIALS FOR NEW YORK. (RMA 9b1 & 9b2 Plant Breeding Project 26-1.)

Leaders: R. P. Murphy, C. C. Lowe, S. S. Atwood, and E. W. Sprague

This report covers the fiscal year 1952-53 (1952 Annual Report, page 56). The progeny testing of selected plants and other research conducted under this project will be reported here separately for each species.

A. Alfalfa

1948 Ranger Increase Study: Further data were obtained from this study in 1952. The results continue to bear out the conclusions of previous years that the present system of certification has maintained a high degree of varietal purity as measured by actual performance under field conditions.

1952 Seed Source Tests with Ranger, Buffalo and Atlantic: A planting was made at Ithaca and one at Aurora to observe the performance of a number of lots of certified, registered, and foundation seed of each of these varieties in order to measure the

effectiveness of the present system of seed certification. Good stands were obtained at Ithaca but they were rather poor at Aurora. No measurable variation among lots was evident in the seeding year.

1948 New York Polycross Progeny Test: This nursery is being maintained as a source nursery for new clones with the emphasis being placed on selection for persistence.

1948, 1949, 1950, 1951, 1952 Uniform Advanced Nurseries: These replicated plot trials are conducted in cooperation with the Division of Forage Crops and Diseases of the U.S.D.A. A number of good clones have been isolated on the basis of these tests of their polycross progeny. Several new experimental varieties have been selected for further testing, such as Vernal and A-225, because of their good performance in these tests. The information on standard varieties, used as checks, has been used along with other tests as a basis for making variety recommendations.

1950 New York Polycross Progeny Test: This trial was harvested for yield for the first time in 1952 and the results indicate that some of the new New York clones have excellent combining ability.

1951 Alfalfa Generation Study: This experiment includes the test of four advanced generations of 19 synthetics and single crosses from the U.S.D.A. breeding program at Lincoln, Nebraska. The results from the first harvest year indicate that there is very little difference in yield between the different advanced generations of a given synthetic. There seems to be a significant drop in yield from the first to the second generation when the synthetic involves only two clones. However, this may not hold true in every case.

Other Variety Yield Trials: (Plant Breeding State Project 9.)

B. Smooth Bromegrass

1950 Polycross Progeny Test: Yields on aftermath and leaf spot were obtained and the outstanding progenies noted.

1951 Polycross Progeny Test: Yields for two cuttings and detailed notes on disease, color, and leafiness were obtained. This test will be continued in 1953.

Isolation Plots of Experimental Synthetics for Seed Production: The seed of the first synthetic generation was harvested from one of these and the seed of the second synthetic generation was harvested from six. It is hoped to get seed this year from three new synthetics. These are tested in regular variety trials against standard check varieties.

Other Variety Yield Trials: (Plant Breeding State Project 9.)

C. Orchardgrass

1950 Polycross Progeny Tests: Yields on aftermath were taken. The clones which produced the best progenies as measured in this test will be selected and used in further breeding work. This test will be discarded in 1953.

1951 Polycross Progeny Tests: Yields were taken on three cuttings and notes on disease, color, and maturity were recorded. Several excellent progenies were observed. This test will be continued in 1953.

Isolation Plots of Experimental Synthetics for Seed Production: Seed of the first synthetic generation of four experimental synthetics was harvested and seed of the second generation was harvested from two. These are or will be tested in regular variety yield trials.

Other Variety Yield Trials: (Plant Breeding State Project 9.)

D. Timothy

1950 Polycross Progeny Test: This test was noted again for leafiness, vigor, and disease reaction and a number of outstanding progenies were observed. From this test several mid-to late-maturing clones have been isolated which seem to be outstanding.

Isolation Plots of Experimental Synthetics for Seed Production: First-generation seed was harvested from four synthetics and second-generation seed from two. Isolation plots for the production of second-generation seed were established for two. These are being tested in regular variety yield trials.

E. Reed Canarygrass

1950 Polycross Progeny Test: Yields on aftermath were taken. This test will be discarded in 1953.

Isolation Plots of Experimental Synthetics for Seed Production: First-generation seed was harvested from four. These are being tested in the regular variety yield trials.

F. Tall Oatgrass

1951 Polycross Progeny Test: This trial was harvested three times and notes were taken on disease and other characters. Yields of aftermath will be taken in 1953.

Isolation Plots of Experimental Synthetics for Seed Production: First-generation seed was harvested from three. These are being tested in the regular variety yield trials.

G. Maintenance Nursery

This nursery has been maintained and necessarily expanded by the

addition of new selected clones from all the species. All clones which are currently being progeny tested or used as parents of an experimental synthetic variety, and all others which might be of some value to the breeding progeam now or in the future are maintained. This maintenance, in itself, is a considerable task.

Title: STRAIN TESTING AND BREEDING OF FORAGE PLANTS FOR NEW YORK STATE AND VICINITY, WITH SPECIAL EMPHASIS ON PROBLEMS OF PRODUCTION DURING PERIODS OF MIDSUMMER DROUGHT (PLANT BREEDING STATE PROJECT 9)

Leaders: R. P. Murphy, C. C. Lowe, S. S. Atwood, A. A. Johnson, H. A. MacDonald (Agronomy), and N. L. Taylor

This report covers the fiscal year 1952-53 (1952 Annual Report, page 58). A summary of the results to date for each species included is given.

During the past seven years, extensive tests have been made of a wide range of forage crops varieties and strains. These have included: (1) commercial varieties now in use, (2) new varieties not yet released that have been developed in New York and elsewhere when they seem of promise, and (3) local ecotypes developed through natural selection; these have been tested against commercial lots commonly available. The tests have been located at four main testing centers for the most part, and in farmers' fields in eight counties.

Considerable use has been made of the data obtained to date. The results have been the basis for the variety recommendations for forage crops. Although the results have not been published in detail, they have been presented to seedsmen and county agents for their use.

Alfalfa: The values of Narragansett, Ranger, and Atlantic have been well demonstrated. Narragansett is the most widely adapted variety, has excellent vigor, is somewhat resistant to common leaf spot, and is the best variety for short-time stands. It is susceptible to the bacterial wilt disease. Ranger, the most winter hardy, bacterial wilt resistant variety, is the best for long-time stands. Ranger has not proved to be sufficiently winter hardy for some areas of Northern New York. Atlantic, which is intermediate in winter hardiness and is somewhat tolerant of the bacterial wilt disease, performs well in the milder areas of the State. Vernal, a new winter hardy and wilt resistant variety recently released in Wisconsin, has shown some promise and is being tested extensively.

Red Clover: Pennscott has proved to be the best variety for the State and will be so recommended when seed is available in quantity in two or three years. Kenland and commercial sorts from New York and neighboring states have been better than other seed. Dollard is being tested more because of its winter hardiness, which may be a factor in Northern New York.

Ladino Clover: Certified seed produced in the Far West and the U.S.D.A. selection F.C. 23,608 have performed better than uncertified seed produced in the United States and most lots of imported seed.

Smooth Bromegrass: Lincoln and other "southern-type" varieties and Manchar have been superior to Canadian commercial lots in establishment, yield, early spring growth, and resistance to foliage diseases. Several of the experimental synthetics appear promising for aftermath production and are being evaluated extensively.

Timothy: Climax and some other late-maturing varieties seem to have promise because of their higher quality at the time most of the timothy in the State is harvested for hay at the first cutting. These varieties are somewhat more resistant to the foliage diseases and leafier. None of the new varieties has been higher in yield than commercial.

Orchardgrass: Several late-maturing experimental synthetics seem of considerable promise since they can be managed better for grazing than commercial. None of these have been higher in yield than commercial. This species is high in aftermath production.

Reed Canarygrass: Ioreed has proved to be as good as any sorts tested to date.

Tall Oatgrass: Tualatin has been about equal in yield to commercial sorts and is slightly later, which is desirable from the standpoint of managing it for grazing purposes. This species is high in aftermath production.

Sudan Grass: Piper has proved to be superior to commercial lots in resistance to foliage diseases. Other new varieties, such as Sweet and Tift, have been too late for good production in this State. The species is useful for providing supplemental grazing in late July and August.

Perennial legumes when stands are good contribute much to the production of hay and pasture during July and August. This is especially true of alfalfa and red clover and to a lesser extent of birdsfoot trefoil. It is also true of Ladino clover unless droughty conditions develop. Of the grasses, orchardgrass is most productive during this period and to a lesser extent smooth bromegrass. The development and use of improved varieties of all of these crops with special emphasis on production during July and August should be of great value.

Title: DISEASES OF FORAGE CROPS

Sub-title: FORAGE LEGUME AND GRASS SEED TREATMENT

Leader: L. J. Tyler

Cooperators: R. P. Murphy, Plant Breeding and H. A. MacDonald, Agronomy

Seedling stands and yields of alfalfa, red clover, birdsfoot trefoil, Ladino clover, smooth bromegrass, orchardgrass, Sudan grass and timothy grown from seed treated with protective fungicides were compared with stands and yields of these species grown from untreated seed. The tests were performed on large, well replicated field plots on the agricultural experiment station farms at Ithaca, New York, in each of 3 years (1950-1952 incl.) and on one farm in each of five widely separated New York counties in 1953. Forage seedings were made with and without a nurse crop.

Analysis of extensive data on seedling stands and yields showed that seed treatment did not increase either stands or yields of any of the crops over those obtained from untreated seed. Arasan and Phygon seed protectants were used in all four years and Orthocide 75 seed protectant was used in some tests in one year (1953). There was strong evidence in the data (although not mathematically significant) that Arasan and Phygon depressed seedling stands of timothy, red clover and Ladino clover in one 1952 test where the seed was planted with oats; the forage seed was sown broadcast immediately after oats were sown, the soil was very dry and the seeded soil was neither rolled nor culti-packed.

A complete report of the results obtained in four years of experiments is being prepared for publication.

Title: DISEASES OF FORAGE CROPS. SUB-PROJECT 4: SURVEY OF FORAGE CROPS DISEASES IN NEW YORK

Leaders: Daniel A. Roberts, Karl D. Fezer, and Robert T. Sherwood

Extensive surveys of forage crops diseases in New York were made in 1952 and 1953, and estimates of crop losses due to diseases were made after percentage of infection and disease severity ratings had been determined. Although losses due to root and crown diseases of complex etiology could not be determined accurately, we believe that these diseases are important factors in legume stand maintenance problems. During the past 2 years the other most serious diseases of forage crops in New York were: common leafspot, spring blackstem, and Stagonospora leafspot of alfalfa; Northern anthracnose, Pseudopeziza leafspot, sooty blotch, Stemphylium leafspot, and rust of red clover; Cercospora leafspot and mosaic diseases of white and Ladino clovers; Stemphylium leafspot of birdsfoot trefoil, brownspot and scald of bromegrass; Heterosporium leafspot and leaf streak of timothy; and leaf streak and purple leafspot of orchardgrass.

This disease survey will be continued until the forage crops disease situation in New York has been evaluated under a satisfactory range of weather conditions.

Title: EUROPEAN CHAFER STUDIES

Leaders: W. G. Evans and George G. Gyrisco

During the summer of 1953 field work was continued on the biology and control of the European chafer, with emphasis on the ecology of the adults and the control of the larvae. The European chafer is an important pest of permanent pasture and other types of sod.

Flight distance studies were conducted by capturing all of the beetles on two widely separated trees every night, marking them with different paints each night, and releasing them at different distances from the trees. Before marking, the beetles were examined for previous markings to obtain the percentages of recovery for different distances, and these data are as follows:

For 80 yards the recovery of marked beetles in one trial was 3.6%.
For 100 yards and 11 observation trials the average recovery was 0.36%.
For 200 yards and 3 trials the average recovery was 0.054%.
For 225 yards and 3 trials the average recovery was 0.026%.

Square foot diggings around six other trees in the daytime showed more beetles per square foot under and near the trees than away from the trees and during the 1952 season marked beetles released near a tree were observed emerging out of the ground and flying directly to the tree. So a general conclusion that can be drawn from this summer's work is that the adult chafer flies to the nearest tree after it emerges from the ground in the evening and does not tend to wander too far away from the area where it spent its larval life.

The oviposition potential of the female was studied in several ways. Alternate plots of bare soil and sod showed preference of sod as site for oviposition, while short foliage and tall foliage showed no significant discrimination.

Everyday during the flight season 25 females were captured and dissected. The data show an average of 19.32 eggs/female on June 19, the beginning of the flight period. This figure increases to a maximum of 25 eggs/female on June 26, then declines gradually to a minimum of 1.76 eggs/female on July 17, the end of the flight period.

Plots of varying pH dug for larval counts showed the highest number to be in plots having a pH range from 6.00 to 7.5.

For control of larvae several of the granulated type of insecticides (aldrin, dieldrin and heptachlor at 2#/acre, and with chlordane at 10#/acre) gave good results. Toxaphene at 20#/acre though highly significant over the check gave only about 50% control.

Title: CLOVER ROOT BORER STUDIES

Leaders: George G. Gyrisco and A. A. Muka

During the past 4 years, spray and dust experiments using dieldrin, isodrin, aldrin, heptachlor, endrin, chlordane, toxaphene, methoxychlor, TDE, parathion, EPN, lindane and BHC were used in 11 different experiments to control the clover root borer. Many of these materials were used in the experiments in 1953.

It was found that although 0.5 pound per acre of aldrin, dieldrin and heptachlor as dusts gave satisfactory control of the borer, a pound per acre gave good results more consistently. One pound per acre of BHC, lindane, isodrin, and chlordane also gave good control but endrin, toxophene, parathion, TDE and EPN gave unsatisfactory control at this and higher dosages.

Preliminary tests with aldrin and lindane applied as emulsions at the rate of 1 pound per acre of actual toxicant gave good control but in general, sprays were less reliable than dusts.

Clover fields which had been properly managed and where disease had not been a serious problem showed increases in persistence of clover from 39 to 71 percent, with clover root borer control.

Title: ALFALFA SNOUT BEETLE INVESTIGATIONS

Leaders: George G. Gyrisco and A. A. Muka

During 1953, further work was conducted using sprays and improved baits for the control of the alfalfa snout beetle.

In the bait tests, when substituted for sodium fluosilicate in the standard bait formula for the alfalfa snout beetle, 1 ounce per acre of isodrin and dieldrin and 2 ounces per acre of aldrin gave better than 98 percent control of the beetles for a period of over 1 month with but a single application. Heptachlor at 2 ounces per acre was nearly as good giving 86 percent control at that dosage. The isodrin experiment was a pilot test encompassing 12 acres.

A bait spreading machine similar to the ones used for spreading grasshopper baits was tried for spreading the peanut shell bait. It gave a 40 foot swath with excellent, even coverage but the bait had a tendency to ball up in the machine. Hence some modification in the feed mechanism is needed if this machine is to be adopted for work on the alfalfa snout beetle.

Lindane, endrin, aldrin and toxaphene were all used as emulsions at the rate of 1 pound per acre of actual toxicant and all showed promising results but infestations were too small in these plots to clearly evaluate these insecticides as sprays and further work using these materials as emulsions is needed.

Title: BIOLOGY AND CONTROL OF THE CLOVER SEED WEEVIL

Leaders: A. A. Muka and George G. Gyrisco

Studies on the biology and control of the clover seed weevil were initiated in 1952 and were continued and expanded in 1953.

It was found that the weevil is responsible for a 25-33 percent loss in red clover seed.

The eggs are laid in the corolla when it is slightly longer than the calyx at a time when the corolla is changing from white to pink. The eggs are laid singly usually at the side of or directly on the unfertilized ovary. In some cases 2 eggs have been observed in the same floret but only 1 larva matures per floret. The eggs hatch and the insect passes through the larval stage in 14 to 23 days.

The insect passes through a prepupal period of 7 to 9 days and a pupal period of 10 to 14 days. The total time from egg to adult is approximately 6 weeks.

Using DDT, methoxychlor and toxaphene at rates from 0.5 to 2.0 pounds per acre of actual toxicant and applying these as emulsions, gave seed increases ranging from 2 to 79 percent.

Title: STUDIES ON THE INSECTS OF BIRDSFOOT TREFOIL

Leaders: H. H. Neunzig and George G. Gyrisco

During 1953 preliminary investigations were undertaken concerning the insects associated with birdsfoot trefoil (Lotus corniculatus L.). These studies were divided into two categories: 1. a determination of which species of insects comprise the complex associated with birdsfoot trefoil, and 2. studies on the clover seed chalcid (Bruchophagus gibbus Boh.), a known destroyer of birdsfoot trefoil seed.

1. To determine the species of insects on birdsfoot trefoil, and relative numbers present, population samples were collected by sweeping stands of trefoil in 10 New York State counties. While it is impossible at this date to discuss the importance of the individual species collected, the data clearly indicate the following insect families to be closely associated with the plant: Cercopidae, Cicadellidae, Miridae, Eurytomidae, Locustidae, Gryllidae, Aphidae, Nitidulidae, Thripidae, Nabidae, Anthocoridae, Coccinellidae, and Apidae.

The families Cercopidae, Cicadellidae, and Miridae represent the major portion of the insect population present in a field of birdsfoot trefoil.

2. Investigations of the clover seed chalcid were based on samples of trefoil legumes collected in 13 counties of eastern and central New York State, and field and laboratory studieson the biology of the insect.

These preliminary investigations show the clover seed chalcid to be established in trefoil stands in all counties investigated. Most counties show a maximum infestation of from 1-2%.

The biological studies indicate that oviposition occurs approximately 10 days after pollination of the trefoil blossom. The length of time required for the development of the chalcid within the birdsfoot trefoil seed is 32 days, with a maximum of 37 days and a mean of 34.5 days. It was observed that peak emergence of the clover seed chalcid occurs during the first two weeks of August.

Title: THE USE OF FUNGICIDES TO PRESERVE MOIST HAY AND GRAIN

Leaders: W. K. Kennedy, R. Bradfield, Roy U. Schenk, J. Thomas Reid, George Trimberger, and K. L. Turk

The studies reported in progress (1952 Annual Report, page 64) were completed. The feeding value of moist hay treated with 2,4,6-trichlorophenol was equal to properly cured hay. The palatability of treated moist hay was higher than untreated moist hay which was quite moldy.

It was found that when moist hay was treated with an effective fungicide and then stored the treated hay continued to remain moist for more than 6 months while untreated hay dried down to 15 percent moisture within 2 to 4 weeks. Untreated hay dries quickly because extensive mold growth releases heat which evaporates the surplus moisture. Heat of respiration is much lower for treated hay so the hay remains moist.

Sodium metabisulfite and benzyl chloride were found to be unsatisfactory as hay preservatives. Salicylaldehyde and the haloketones offer some promise as moist hay and grain preservatives.

Title: THE INFLUENCE OF IRRIGATION AND NITROGEN FERTILIZER ON THE YIELD OF DIFFERENT LEGUME-GRASS MIXTURES

Leaders: W. K. Kennedy, H. E. Gray and G. Levine

Work reported earlier (1952 Annual Report, pages 63-64) has been continued with much the same results regarding the response of legume-grass mixtures to nitrogen fertilization. In the first harvest year very economical yield increases of forage were obtained from applying up to 200 pounds of nitrogen per acre to Ladino clover-grass mixtures. Ladino clover-orchardgrass has been higher yielding than Ladino clover-bromegrass or Ladino

clover-timothy. However, the Ladino clover was eliminated from the orchardgrass mixture but remained as a good stand in the bromegrass and timothy mixtures. If nitrogen fertilization was continued for the second and third harvest year the response to nitrogen in all mixtures was small.

Attempts to prevent this decline in yield by careful liming and heavy fertilization with phosphorus and potassium were unsuccessful. It was found that continuous nitrogen fertilization, plus cutting five times during the growing season, reduced the ratio of roots to top growth. Root growth of bromegrass was decreased more than root growth of orchardgrass. It is possible that the decline in root reserves accounts for the decreased response to nitrogen fertilization in the second and third harvest years.

The increase in yield from irrigation during 1952 and 1953 was from 800 to 1800 pounds per acre of dry matter. In these drier-than normal-years the increase in yield would just about cover the costs of irrigation. No additional benefits from irrigation such as better maintenance of stand were obtained.

Title: A STUDY OF FACTORS AFFECTING THE SEEDLING ESTABLISHMENT OF FORAGE PLANTS

Leader: H. A. MacDonald

Further studies on phases of this project previously reported were continued during 1953. Special attention was devoted to investigations relating to time of seeding, influence of moisture and drought, hard seed, seed treatment and management during seedling development.

The best seedling establishment was obtained from early spring seeding on a prepared seedbed. Late fall and winter seedings were severely injured immediately following germination or by frost heaving prior to firm establishment. Late spring and late summer seeding gave intermediate results. The merit of spring seeding was largely controlled by soil fertility and weed competition, while summer and fall seedings were more adversely influenced by available moisture and the short period of development prior to winter. A large number of trials has shown that limited soil moisture is very frequently the controlling factor in seedling establishment, particularly during seasons of high temperature and rapid evaporation. With adequate moisture available, summer seedings were superior to other dates.

Hard seeds present in alfalfa, Ladino white clover and red clover were found to depreciate the merit of stand establishment only slightly. The problem in birdsfoot trefoil was found to be serious due to delayed germination. Seedlings from hard seeds which did not germinate for a period of six weeks or more following seeding were largely eliminated due to competition and did

not contribute to the stand or yield of forage. Hard seeds were of maximum value where germination occurred in the spring following drought or winter injury to the plants initially established.

Seed treatment for the control of seedling insects or disease has shown to be ineffective in the trials to date.

Clipping of established forage crop seedings during the seedling year reduced the growth and strength of stand of pure, well spaced seedings. This reduction was outweighed, however, by its reduction of weed competition and elimination of disease and insect affected plant pores in which respiration exceeded photosynthesis.

Title: THE EFFECT OF STAGE OF GROWTH WHEN HARVESTED UPON THE YIELD, CHEMICAL COMPOSITION AND LONGEVITY OF THE PRINCIPAL FORAGE GRASSES AND LEGUMES

Leader: H. A. MacDonald

The work of this project as outlined last year (1952 Annual Report, page 63) was continued during 1953 with special emphasis being devoted to white clover and birdsfoot trefoil types and varieties.

The influences of climatic conditions, soil moisture and the level of available soil fertility were found to be so important as to nullify, in many cases, the influence of wilting treatment on yield and persistence. Future studies must be more specific and detailed if basic data for general application are to be obtained.

The results of this study are being analyzed and prepared for publication.

Title: STUDIES OF BIRDSFOOT TREFOIL AS A FORAGE LEGUME IN NEW YORK

Leaders: H. A. MacDonald and J. Fuelleman

Investigations relative to seeding establishment, management for hay and pasture, seed production, hard seed control and plant nutrition was continued during 1953. Further work was devoted to plant improvement and the increase of selected material for further study.

Improved seedling establishment of birdsfoot trefoil was obtained when seedings were made at a period during which the soil was worse, yet possessed adequate moisture for quick germination and growth. Seed certification effectively overcame the problem of hard seed but resulted in minor injury to total germination. Preliminary evidence indicated the superiority of certain strains of rhizobium for nitrogen fixation resulting in stronger establishment of young seedlings.

Previously reported results indicating compatibility of birdsfoot trefoil in mixtures with timothy and bromegrass, but not with orchardgrass, must be modified to the extent that the earlier varieties make desirable associations with orchardgrass. The merit of any association has been found to be more dependent upon the growth, form and habit of the varieties involved and the management system to which the mixture is subjected than to the species per se.

Seed production problems continue to be the major obstacle to the more extensive use of birdsfoot trefoil. While much has been learned concerning methods of seed production, harvest and cleaning, no certain solution has yet been found for the problem of bud drop or loss of seed by shattering. Both are under investigation.

Plant improvement efforts have been directed toward the development of a hardy, high yielding variety possessing resistance to insect and disease injury. The Viking variety now being increased possesses the desired qualities only in part and attempts are being made to improve it.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF RED CLOVER

Leaders: H. R. Fortmann and R. W. Cleveland

In a variety trial conducted at State College, Pennscott showed marked superiority in the second harvest year over five other varieties. In another variety trial at State College, Pennscott did not show significantly higher yields than five other varieties tested in the first harvest year, 1953. A yield trial including several seed lots of Pennscott red clover and breeder Kenland red clover was established at State College in the past year.

In a graduate research problem being undertaken by Mr. Richard Latterell, 121 lines of red clover are being inoculated with Sclerotinia trifoliorum in an effort to isolate individuals resistant to the depredations of this organism. The lines now in study are open pollinated progenies of plants selected for apparent disease resistance in a disease nursery.

Two generations of selections and progeny testing for disease resistance have preceded the present generation being studied. The original source material was derived from six varieties of red clover. It is hoped that we may obtain a measure of the efficiency of this type of selection program in breeding for disease resistance of a complex genetic nature.

Title: THE GENETICS AND IMPROVEMENT OF BIRDSFOOT TREFOIL

Leaders: H. R. Fortmann and R. W. Cleveland

Variety yield trials conducted at State College in 1953 have continued to indicate that Viking is one of the better yielding varieties when managed as silage or hay. Seed from one European source has shown no significant difference in yield from Viking. Generally, seed from European sources is satisfactory for Pennsylvania conditions. Seed has been harvested in 1951, 1952, and 1953 from two polycross nurseries, one consisting of 35 clones selected out of the Empire variety, and the other consisting of 79 clones selected from European seed stocks of birdsfoot trefoil. Polycross progenies of these clones from the polycross nurseries are being evaluated as to yielding ability, establishment, and persistence in plantings established in 1952 at Landisville, Pennsylvania and at State College, Pennsylvania. The better clones will be evaluated in the Northeast, beginning in 1954.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: H. R. Fortmann, and R. W. Cleveland

Primary emphasis in this project is devoted to orchardgrass, bromegrass, timothy, and Reed canarygrass.

Orchardgrass: Evaluation of clones selected at the Pasture Laboratory has been continued during the past year. Seed of 150 promising clones, established in polycross nurseries at State College in 1951, was harvested during the 1953 season. There are good amounts of polycross seed for most of these clones. The clones were evaluated as to incidence of leaf diseases and aftermath vigor. Polycross progenies of a limited number of the better clones will be evaluated regionally as to yield, establishment, and persistence of stand beginning this coming planting season.

Restricted polycross nurseries were established in 1953 of three orchardgrass synthetics developed by the Pasture Laboratory which have been reconstituted with a new clonal formulation. The first seed harvest of these synthetics will be made in 1954.

Reconstituted Synthetic No. I

Clones

MI - 14
MII - 34
MII - 36
MII - 56

Reconstituted Synthetic No. II

Clones

MIII - 8
MIII - 18
MIII - 20
MIII - 24

Reconstituted Synthetic No. III

Clones

MIV - 5
MIV - 17
XLI - 8
XLI - 17

A new polycross seed production nursery of selections from an old source and polycross progeny nursery was established the past season. Open pollinated seed from the above selections was seeded in a yield trial experiment. Establishment of this planting is dubious.

Bromegrass: Evaluation of selected bromegrass clones by means of their polycross progenies has been continued during the last season. Yields in 1953 of New York synthetics have been evaluated. Experiments at State College with bromegrass varieties have continued to show Achenbach, Lincoln, and Fischer almost identical with respect to average yield. In most cases they were higher yielding than Martin and Manchar, which were nearly the same.

Timothy: Variety yield trials were continued for timothy. Difference between all varieties tested at State College in 1953 were not great enough for significance.

Reed Canarygrass: At the present time this species is little used as a forage plant in Pennsylvania but has many qualities which could make it useful under some conditions. The main criticism of Reed canarygrass is its lack of palatability to dairy cattle. A closely related species, Harding grass (Phalaris tuberosa var. stenoptera), is quite palatable to animals but is not well adapted to culture in the northeastern United States. An F_1 hybrid between Phalaris arundinacea and Phalaris tuberosa has been found by R. M. Love of the University of California. Self-pollinated seed of this hybrid was obtained from Love for evaluation in this region. A planting of this material will be established in 1954.

Title: THE GENETICS AND IMPROVEMENT OF ALFALFA (MEDICAGO SATIVA L.)

Leaders: H. R. Fortmann and R. W. Cleveland

Evaluation of material in uniform nurseries, variety trials, etc. in 1949 and subsequent years was continued. New plantings consisted of the Uniform Variety trial developed for the Northeast region and a trueness-to-type test of some 400 entries of various sources of the more important varieties.

Title: THE EFFECTS OF SOIL COMPACTION IN PERMANENT PASTURES

Leaders: R. B. Alderfer, Penna. and R. R. Robinson, Pasture Laboratory

The effect of soil compaction on runoff losses and yields of herbage is being investigated on an old Kentucky bluegrass sod. The soil which was originally mapped as Hagerstown silt loam, is located near the bottom of a long slope and is partially colluvial material. Soil structure on the control plots is very good. Replicated plots were compacted in the spring (May 18) with a heavy short-coupled truck when soil moisture was near field capacity. Subsequent treatments on compacted plots included use of an acrifier and of cultivation to simulate the action of the Graham-Hoeme plow.

In the first year of the trials compaction markedly increased runoff. Plots that were acrified or cultivated following compaction lost very little more water than non-compacted plots. However, the season was characterized by heavy rains in the spring followed by a dry summer. Most of the runoff, therefore, occurred in the spring when soil moisture was not a limiting factor. The yields of dry matter on the compacted plots averaged about 65% of those on the non-compacted plots. The use of an acrifier or other cultivation treatments did not increase yields of dry matter.

Title: FORAGE AND PROTEIN PRODUCTION OF NITROGEN FERTILIZED GRASSES WITH GRASS-LEGUME ASSOCIATIONS

Leaders: J. B. Washko and R. F. Pennington

The summary of three years' data is given below (1951 Annual Report, page 75, 1952 Annual Report, page 72). This problem is being studied further in more carefully controlled greenhouse experiments.

SUMMARY:

1. Highest forage yields were obtained with 100 pounds of nitrogen for three of the five grasses: orchardgrass, Reed canarygrass, and tall oatgrass. These grasses fertilized with nitrogen produced significantly higher yields than when grown in association with any of the three legumes -- Ladino clover, alfalfa, and birdsfoot trefoil.

2. All five grasses -- orchardgrass, bromegrass, Reed canarygrass, tall oatgrass, and timothy -- yielded more forage in Ladino clover associations than in alfalfa and birdsfoot trefoil associations.

3. All five grasses with nitrogen fertilization produced two or more tons of forage for the first cutting, whereas only one legume-grass association, namely, Ladino clover and timothy produced this amount of forage.

4. The highest aftermath production was obtained with tall oatgrass, orchardgrass, and Reed canarygrass respectively. Nitrogen fertilization again produced larger yields of aftermath than the legume-grass associations.

5. The most productive tall-growing grasses, irrespective of treatment or legume association, were orchardgrass and tall oatgrass. The least productive was bromegrass. Reed canarygrass and timothy were approximately equal.

6. There was considerable species interaction with location and years. Meadville was most favorable for forage production and State College next best. The first two years, 1950 and 1951, were more productive of forage than 1952.

7. The protein content of the grasses in legume associations was slightly higher than for the grasses grown in pure stands with nitrogen fertilization. Differences for the first cutting approximated 1/2% and for the second cutting 2% in favor of the legumes.

8. Despite the slightly higher protein composition of the legume associations over pure grass stands when converted to production of protein per acre, highest protein yields were obtained from the grasses grown alone with nitrogen fertilization. Orchardgrass with nitrogen thus produced the highest yields of dry matter per acre and also produced the largest amount of protein per acre.

9. Highest protein production was obtained at the most favorable locations for forage production, namely, Meadville and State College.

10. Protein production was highest in the first two years, 1950 and 1951, and lowest in 1952, regardless of species or treatment.

11. No one grass was superior to all others in protein production under all conditions.

12. When the effects of various legume-grass associations and commercial nitrogen in the amount of 100 pounds annually are compared, highest protein production per acre was obtained from the commercial nitrogen and Ladino clover, and alfalfa associations were found to be superior to birdsfoot trefoil production.

13. Finally, these data indicate that nitrogen fertilization not only will produce larger yields of dry matter per acre when used with the five grasses grown alone in this experiment, but the quality of the resulting forage (judged by yield of protein per acre) is just as high or higher as when the grasses are grown in legume associations.

Title: RENOVATION OF UNPRODUCTIVE PASTURES

Leaders: J. B. Washko, R. S. Leach, and W. J. Kjelgaard

Forage yields were obtained during the summer of 1953 at two locations. Tall oatgrass, timothy, and bromegrass in association with Ladino clover, Empire birdsfoot trefoil, or Viking birdsfoot trefoil were higher yielding than common orchardgrass, S-37 orchardgrass, or Reed canarygrass with the same legumes. Reed canarygrass, however, gave the highest mid-summer production. Areas that were fertilized with 500 pounds per acre of superphosphate (20%) in the fall and 400 pounds per acre of 5-10-10 prior to seeding in the spring produced the highest forage yields followed by treatments of 500 pounds per acre of 0-20-20 fall applied in that order. Ladino clover grown with various grasses gave higher yields on areas that were prepared by surface tillage (cutaway disk, field cultivator, or multiple chisel plow). Empire and Viking birdsfoot trefoil produced more forage on plowed areas (moldboard, disk plow). The forage yields obtained on areas that were treated with 50 pounds per acre of Sodium TCA were influenced by the density of the original sod. On densely vegetated areas yields were similar to those obtained by surface tillage. On sparsely vegetated areas the results approximated those obtained by plowing.

Additional experiments were initiated in the fall of 1952 and 1953. The degree of sod kill obtained with the various tillage implements and chemicals in the 1952 experiment was as follows: Moldboard plow 98 percent, Multiple chisel plow 85 percent, Disk plow 90 percent, Cutaway disk 95 percent, Sodium TCA 95 percent, and CMU 65 to 85 percent. Satisfactory stands of legume-grass mixtures were obtained in 1953 on all areas except those treated with CMU where only partial stands of birdsfoot trefoil were obtained. The 1953 experiments include two sod treatments, Dalapon and a new type of cutaway disk, not included in previous experiments.

Title: FORAGE AND GRAIN PRODUCTION OF WINTER SMALL GRAINS AS INFLUENCED BY FERTILIZATION AND MANAGEMENT PRACTICES

Leaders: J. B. Washko, J. L. Edge, R. F. Pennington, and L. L. Haskins

Three years of work was completed in 1953 on a grazing experiment which embodied the following factors: different nitrogen applications, time of forage removal, method of seeding (rows versus cross drilling), method of forage removal (clipping versus grazing) and

two winter grains (barley and wheat). Fall forage removal either by clipping or grazing was less harmful to grain production than both fall and spring forage removal. Differences in forage production and grain production due to method of seeding were minor. Nitrogen applied at 120 pounds per acre in a split application of 60 pounds before seeding and 60 pounds spring applied was more effective in increasing forage production, whether grazed once in the fall or twice -- both fall and spring, than 80 pounds split into four 20-pound applications. Applications of 400 pounds per acre of an 0-20-20 fertilizer preceded seeding of the grains. Winter barley was more productive than winter wheat both in forage and grain. When the forage and grain production were converted into T.D.N. production, winter barley yielded from 3,533 to 4,421 pounds and winter wheat from 2,916 to 3,300 pounds of T.D.N. per acre with such fertilization.

Title: YIELDS OF VARIOUS FORAGE SPECIES UNDER IRRIGATION

Leaders: R. B. Alderfer and J. B. Washko

Supplemental irrigation was applied to various legumes and legume-grass combinations for the third year in 1953 (1952 Annual Report, pages 74-75). The only change from the previous year in this experiment was that 160 pounds of nitrogen per acre were applied in split applications of 40 pounds each after each cutting on the orchardgrass-Ladino clover and Kentucky bluegrass-white clover plots. Irrigation was initiated on June 22 and concluded on September 3. A total of 4.8 acre inches of water in four applications was applied to the plots simulating pasture conditions at level (1) and 5.6 acre inches were applied at level (2). On the plots managed for hay 1.6 acre inches were applied in two applications at moisture level (1) and 4.0 acre inches in four applications at level (2). Both the Ladino and white clover stands were so poor that the contribution to forage production was minor.

Herbage production for 1953 (only during the irrigation period) is summarized in the table below. Alfalfa alone and in combinations with bromegrass produced highest forage yields irrespective of moisture level. Differences between the check plots and those receiving 4.0 acre inches approximated a quarter of a ton of hay or less -- certainly not an economical return for the water applied. The yields of the pasture grasses regardless of moisture level maintained were low. The application of 160 pounds of nitrogen increased production from .51 tons per acre for orchardgrass and .68 tons per acre for bluegrass even without irrigation. With this level of nitrogen fertilization, differences in yield between orchardgrass and Kentucky bluegrass were insignificant at comparable moisture levels.

Yields of forage under different irrigation treatments, June 22 to September 3, 1953.

Dry Matter Productions - Tons/Acre

Species	Moisture Levels					
	Without Nitrogen			With Nitrogen		
	Check	Wilting Point	1/2 Field Capacity	Check	Wilting Point	1/2 Field Capacity
Ky. blue-white clover	.11	.23	.33	.79	1.23	1.53
Orchard-Ladino clover	.29	.45	.75	.80	1.29	1.48
Brome-alfalfa	2.10	1.98	2.23	---	---	---
Alfalfa	1.93	1.94	2.23	---	---	---

Title: GRAZING NEW STRAINS OF LEGUMES AND GRASSES IN MIXTURES

Leaders: J. B. Washko and P. S. Williams

The following legume-grass mixtures were seeded in 1952 on one-half acre paddocks, replicated three times: Buffalo alfalfa-S-37 orchardgrass, Empire birdsfoot trefoil-Tualatin tall oatgrass, Empire birdsfoot trefoil-S-37 orchardgrass , Empire birdsfoot trefoil-Reed canarygrass, and birdsfoot trefoil-timothy-Kentucky bluegrass. In 1953 the first forage harvest from these plots was ensiled and the subsequent aftermath grazed with dairy cattle. The production from these mixtures in terms of dry matter for the season on an acre basis were: alfalfa-late orchardgrass 3.77 tons, birdsfoot trefoil-tall oatgrass 2.97 tons, birdsfoot trefoil-timothy-Kentucky bluegrass 2.80 tons, birdsfoot trefoil-late orchardgrass 2.60 tons, and birdsfoot trefoil-Reed canarygrass 2.51 tons. T.D.N. production in tons per acre for the season by these mixtures in the order previously listed was respectively 5500, 4360, 4133, 3813, and 3927.

Title: THE INFLUENCE OF FERTILIZERS APPLIED AS TOPDRESSINGS ON FORAGE CROP PRODUCTION, LEGUME MAINTENANCE, QUALITY, AND THE MOVEMENT OF NUTRIENTS IN THE SOILS

Leaders: R. P. Pennington and Boyd W. Ghering

Objectives:

1. To study the effect of different amounts and ratios of fertilizers on the maintenance of legumes and yield in legume-grass mixtures.

2. To correlate fertilizer applications and soil tests.

3. To study the effect of these ratios and amounts on nutritional value of the forage.

4. To study the effect of one element on the plant uptake of that and other elements by both grasses and legumes.

5. To study the movement in soils of the fertilizer nutrients applied as topdressing.

PROCEDURES: One replication of a complete factorial experiment consisting of five levels of nitrogen -- 0, 20, 40, 80 pounds -- per acre and 40 in the fall and 40 after first harvest. Four levels of P_2O_5, 0, 40, 80, and 160 pounds per acre. Four levels of K_2O, 0, 40, 80, and 160 pounds per acre plus additions of borax and trace elements at the high and low level of each major nutrient.

Six of these areas have been fertilized -- three on alfalfa mixtures and three on birdsfoot trefoil mixtures. Other areas will be fertilized this spring. Each of these areas has 104 individual plots. These plots will be harvested and yields of dry matter obtained. The forage and soils from each area will be analyzed chemically to obtain information as to the effectiveness of fertilizer usage and movement in the soil.

Title: MEASUREMENT OF THE NUTRITIVE VALUE OF PASTURES AND PASTURE PLANTS

Leaders: R. L. Cowan, J. W. Bratzler and R. W. Swift, The Pennsylvania Agricultural Experiment Station. J. T. Sullivan and V. G. Sprague, Pasture Research Laboratory.

Previously reported work (1952 Annual Report, page 78) indicated that sodium meta-bisulfite applied in water solution was effective in preserving grass silage. During 1952, using applicators adapted from corn planter fertilizer equipment, anhydrous sodium bisulfite powder was added through the forage blower to unwilted crops ensiled in 5' x 20' experimental silos, and in 3 larger (farm size) silos, resulting in uniform distribution and excellent preservation of the silages. Losses of digestible nutrients, determined by weighing and analyzing the ingoing and outgoing materials ensiled in the 5' x 20' silos, and digestion trials with sheep, indicated that the bisulfite treatment significantly reduced losses of the more digestible fraction of the N-free extract, when compared with no preservative and molasses treatments. This effect was not so marked when orchardgrass harvested after heading was the crop ensiled, as it was in the case of alfalfa-bromegrass harvested pre-bloom. In the latter case, savings of T.D.N. worth about $1.75 resulted from treatment of each ton of alfalfa-bromegrass with 7.5 pounds of bisulfite, costing about $.50.

In free-choice palatability trials, it was found that the amounts of bisulfite treated silages consumed by dairy heifers were almost four times those of SO_2 treated and no preservative silages.

During 1953, field trials were conducted with the cooperation of 50 Pennsylvania farmers, and the Agricultural Extension Service. Bisulfite supplied by the manufacturer was applied to silages on these farms, under College supervision and on a demonstration basis. In all of the silages observed to date, results have been excellent; the silages are bright green in color, free from strong odor, and very palatable to cattle.

Title: THE EVALUATION OF GRASSES AND LEGUMES FOR HAY, SILAGE AND PASTURE

Leaders: P. H. Margolf, M. G. McCartney, J. B. Washko, R. P. Pennington, and A. L. Haskins, The Pennsylvania State University. V. G. Sprague, Pasture Research Laboratory.

EXPERIMENT III

Evaluation of orchardgrass, bromegrass, Reed canarygrass, Kentucky bluegrass, and Ladino clover with White Holland male poults placed on range at 10 weeks of age, and fed a low protein all-mash diet from 12, 14, and 16 weeks of age to 28 weeks.

Triplicate areas, (each consisting of five one-acre plots) of good stands of orchardgrass, bromegrass, Reed Canarygrass, Kentucky bluegrass and Ladino clover, one species only to each of the one-acre plots in each replication were used for range. The experiment was begun March 2 and ended October 13, 1953.

Three groups of 600 White Holland turkey poults were hatched and sexed March 2, 16 and 30 respectively. After sexing, approximately 300 male turkey poults were available for each of the three areas. All hatches were brooded and reared in confinement until they were 10 weeks old. At 8 weeks of age they were banded.

When each hatch of the banded poults was ten weeks old, on May 12, May 26, and June 9, respectively, the poults were moved to range. At this time they were separated at random into five groups and each group placed on one of the five one-acre plots in each replication.

All poults were fed The Pennsylvania State University starter mash mixture 28% protein, until 8 weeks of age, and the developer mash Mixture A from 8 to 10 weeks. On range the mash mixtures were fed in pellet form. Developer mash Mixture A pellets were fed to all poults until June 22 when the poults were 16, 14, and 12 weeks of age. Ration C was then fed to the birds until the end of the experiment. A special group of the 12 weeks old poults received Ration B instead of Ration C on June 22 and for the duration of the experiment.

The three developer rations used varied in their protein and vitamin content. Ration A contained 20% protein of animal and vegetable origin with vitamins and minerals added, Ration B contained 14% protein of animal and vegetable origin with reduced amounts of animal protein and vitamins, and increased grains, Ration C with 11% protein, was composed of only grains and minerals.

A continuous supply of succulent green forage was available throughout the experiment to the 45 to 50 poults on each acre plot.

Protein content of the herbage on range, the seasonal gain in weight of the birds and the pounds of grain fed on ranges where 5 forage species supplied succulent feed.

	Legume	Grasses			
	Ladino Clover	Reed Canary-	Kentucky Blue-	Brome-	Orchard-
1. Protein (percent)*	27.0	22.6	23.0	21.4	19.5
2. Gain in Body Weight (pounds) 10-28 weeks	16.3	16.0	16.4	16.1	15.3
3. Pounds of Feed Used per Pound of Gain	3.5	3.8	3.9	3.9	4.1

* Average composition of herbage harvested at six intervals from May 13 to September 14.

CONCLUSIONS

When succulent green pasture was continuously available to growing tom turkeys fed a low protein level pelleted mash mixture, Ladino clover, compared with four grasses, gave the best efficiency in pounds of feed per pound of gain.

A supplementary experiment indicated that the low level protein pelleted mash mixture compared favorably with a higher level protein mash mixture fed to growing tom turkey poults on range when succulent green pasture was continuously available.

Title: FORAGE INSECT INVESTIGATIONS

Leader: Norris D. Blackburn

Further studies on the control of the meadow spittlebug and root borer on red clover (1952 Annual Report, pages 78-79) were conducted during 1953 with special reference to insecticidal residues remaining on the hay at harvest.

Insecticides were applied as sprays on a high-gallonage basis in the form of emulsifiable concentrates against the nymphs of the meadow spittlebug, and as wettable powders at higher concentrations against root borer adults both before and during the peak of migration flight. Results from residue determinations made on the hay at harvest were inconsistent for some of the materials, but for others the results showed considerable uniformity. Some of the latter results are summarized in the table below.

Average residue levels (dry weight basis) on red clover at harvest following insecticidal treatments applied at different times during the spring for control of the meadow spittlebug and clover root borer.

Insecticide	Amount of toxicant per acre	Residues in ppm. and associated intervals - treatment to harvest			
		58 days	51 days	44 days	37 days
Dieldrin	0.25 lb.		<0.1	<0.1	
Lindane	3.15 oz.		0.2	0.3	
Methoxychlor	0.5 lb.		0.1	0.2	0.2
do	1.0 lb.			0.9	
Toxaphene	1.5 lb.		1.4	4.0	
Gamma benzene hexachloride*	1.25 lb.	0.3	0.5	0.4	1.0
Dieldrin*	0.8 lb	<0.1	<0.1	<0.1	0.3

* Applied specifically for control of the clover root borer.

Experimental post-harvest treatments for root borer control included gamma benzene hexachloride, dieldrin, chlordane, and heptachlor applied as wettable powders at the rate of 1.25, 0.8, 5.0, and 1.0 pounds per acre, respectively. Each was used alone and in combination with a fungicide about one week after the first cutting of clover. With exception of benzene hexachloride, none of the treatments resulted in a significant reduction of subsequent root-infesting populations. No increase in late-season plant survival was associated with any of the treatments.

RHODE ISLAND

Title: MANAGING PASTURES UNDER RHODE ISLAND CONDITIONS FOR MAINTAINING LEGUMES AND FOR SUSTAINED YIELDS.

Leaders: Irene H. Stuckey, James W. Cobble, Donald A. Schallock

Fourteen half-acre plots of Ladino clover-orchardgrass mixture were grazed for the first time in 1953. Four treatments were used: 3 plots, close, frequent grazing all summer; 4 plots, cut for silage when the grass head was just out of the boot, followed by close grazing the rest of the summer; 3 plots, moderate grazing all summer;

4 plots, a silage cut followed by moderate grazing. A fifteenth plot, the control, had the forage removed with a forage chopper four times during the summer.

Yields and botanical composition were estimated from samples cut before each grazing period. The plots were clipped following grazing once for the silage plots and twice for the plots which were grazed all summer.

Two lots of yearling heifers were used for grazing, one for the moderate grazing plots and the other for the severe grazing. Within each lot, the individual pastures were grazed one at a time in rotation independent of the other lot. The heifers were weighed at the beginning and again at the end of the grazing season.

The evidence from one season's results is not conclusive, but the grazing ended sooner on the severely grazed plots. The grass on the severely grazed plots was somewhat stunted and the percentage of legume was greater than on the moderately grazed plots. By December 22 there was evidence of severe damage from disease on the clover on these plots and a decrease in the stand of clover.

The increase in weight and stature of both lots of heifers was normal. There were no real differences between the two lots.

Title: BREEDING IMPROVED ALFALFA FOR THE EASTERN UNITED STATES

Leaders: T. E. Odland and J. E. Sheehan

The breeding work with alfalfa was limited to maintaining the material in the fields, while the leader of the project was away on sabbatical leave.

The production of breeder seed of Narragansett alfalfa was continued. There will be about 40 pounds to go into storage for future use. Sufficient foundation seed acreage is now in production to supply present needs. It is estimated that about 125,000 pounds of certified Narragansett seed will be available for planting in the spring of 1954. It is expected that the 1954 crop will yield about 2 million pounds of certified seed. This should be enough to very nearly supply demands for this variety.

Three cuttings were taken from the two uniform alfalfa nurseries. Yields ranged from 1.52 tons per acre for Nevada A224 to 3.21 tons for Narragansett. The latter variety continues to give the best yields. A detailed report on these two nurseries has been submitted.

Title: SOIL FERTILITY AND SOIL MOISTURE RELATIONS IN GRASSLANDS OF THE NORTHEAST

Leaders: Donald A. Schallock, Irene H. Stuckey, Milton Salomon, and Robert Beverage

A Ladino clover-bromegrass stand gave excellent response to varying levels of P_2O_5 and K_2O on the experimental area initially low in fertility and no response during this third year on the area with moderate fertility levels. See table.

Soil and plant samples are being analyzed for potassium to determine relationships between plant feeding and fixation and loss of potassium in the soil.

Response of Ladino clover and bromegrass to various fertility treatments

	Annual Treatments Pounds per acre		1953 Yield Tons per acre (oven dry)
	P_2O_5	K_2O	
1	0	0	.8
2	0	240	1.1
3	30	240	2.5
4	60	240	2.9
5	120	240	2.9
6	120	0	1.3
7	120	30	2.1
8	120	60	2.5
9	120	120	2.7
10*	120 (Top dressing)	240	2.3
11*	120 (Worked into soil)	240	2.1
12*	120 (In bands)	240	2.2
13	240	240	3.1
14	120 (Plus 2.5 lbs. Boron)	240	3.3

* Phosphorus applied only at the beginning of the experiment

LSD @.05 = .42 T/A

The analysis of plant material has not been completed, but preliminary reports show that the percent of elemental potassium in the oven dry tissue increased steadily from .95% at the zero level of applied potassium, to 2.42% at the 240-pound K_2O level of fertilization. There was no appreciable increase in the accumulation of residual potassium in the readily available form until the 240-pound application, at which time it jumped from 75 to 162 pounds K per acre in the top six inch layer of soil.

Title: POTASH SOURCES AND RATIOS

Leaders: Donald A. Schallock, T. E. Odland and Robert Beverage

Yields of Ladino clover and bromegrass hay and aftermath pasture were highest at the 0-120-120 level of fertilization. The crops removed more potassium in the first cutting than was applied in the fertilizer up to the 160 pound level of K_2O per acre. The third cutting was grown at the expense of the soil minerals or from previously applied fertilizer.

The application of potassium up to the 0-120-120 level decreased the calcium supply in the plant but not to the extent of reducing the feeding quality of the roughage.

VERMONT

Title: CYTOGENETICS AND BREEDING INVESTIGATIONS WITH FORAGE LEGUMES

Leaders: A. Gershoy and Glen Wood

Polyploid Ladino Clover, T. repens var. latum 2n = 64: Most of the seed increase obtained in 1953 in Madras, Oregon, has been set aside for a larger increase in the same area with the cooperation of the Oregon Agricultural Experiment Station. Some seed will be distributed by the U.S.D.A. for regional trials under both standard practices and under conditions of higher soil fertility and supplemental irrigation. A more rigorous selection of parent clones will be made with severe competition by associated grasses.

Broad-leaf Birdsfoot Trefoil, Lotus corniculatus: Data for yields in combined first and second year harvests, in plots managed for hay and silage, and presented elsewhere in the Vermont report, by Glen Wood (cf 1952 Annual Report). The Vermont, European type, synthetic strain (Mansfield) shows yields comparable with those of the N. Y. Viking strain. The trefoil fraction has not declined, in plots with associated grass. The Mansfield strain has again yielded two seed crops in one season under Vermont conditions. Foundation seed increase is being augmented. Reselection of parent types is being made in breeder seed fields.

Autoploid Narrowleaf Birdsfoot Trefoil, 4n = 24: Maternal-line progeny selection studies are being continued in advanced generations of open pollinated autotetraploids. The percentage increase in fertility has been comparatively low, following mass plantings of the most fertile family lines. Imperfect and slow-maturing seeds continue to appear in all lines in fairly high but variable percentages. Comparison plot trials for forage yields in these polyploids, in grass association, are being continued.

Hybrids Between Lotus corniculatus and tetraploid L. tenuis: Vigorous F_1 hybrids, obtained by crossing of several individual plants of advanced generations of autoploid L. tenuis with several individual plants of L. corniculatus have shown high fertility under open pollination in the greenhouse (Miss Kathy Mears). Also, the percentage of imperfect and slow maturing seeds is quite low in the majority of these hybrids. In addition to small and medium sized, poor grains, two distinct classes of pollen occur in the F_1: (1) broadly elliptical large grains which germinate well and produce normal tubes on sugar-agar, and (2) round, large grains which germinate poorly and produce short, abnormal tubes. A tentative hypothesis, designed to explain the unexpected high fertility of the F_1, will be tested in cytogenetic studies. The progeny of the F_1 will be studied in the field for seed set and growth characteristics. Bulked seed of the F_1 and F_2 will be gathered for preliminary plot trials, for forage yields.

Chromosome Studies in Lotus Species: The gross morphology of somatic chromosomes in the 2n = 14 species, yellow flowered L. crinthopcides, pink flowered L. arabicus and in an undetermined yellow flowered, autogamous form with curved pods, is quite unlike that in 2n = 12 species. All 2n = 12 species (yellow flowered) appear to have similar genoms and apparently show identity with the genom sets in 2n = 24, yellow flowered species.

Title: TREFOIL STRAIN TRIALS

Leaders: G. M. Wood and T. R. Flanagan

The 1953 relative performances of four trefoil strains in two grass associations was essentially the same, with one exception, as in 1952 (1952 Annual Report, pages 81-82). Viking, although lower yielding in 1952, produced as much forage in 1953 as did the Mansfield strain (formerly called Vermont 1).

Summary 1952-53 Trefoil Strain Trials
Burlington and Addison, Vermont

Total Dry Weights of Birdsfoot Trefoil Fraction in Tons per Acre

ASSOCIATIONS	STRAINS				
	Mansfield	Viking	Granger	Empire	Association Mean
Alone	1.30	1.21	.91	1.02	1.11
Climax Timothy	1.33	1.26	1.09	.73	1.10
Late Finnish Orchardgrass	1.18	.97	.91	.71	.94
Strain Mean	1.27	1.15	.97	.82	

LSD (Means)			
Strains		Associations	
5%	1%	5%	1%
.15	.19	.13	NS

A rainfall deficit of nearly 3 inches for June-July in 1953 apparently favored the deeper rooted birdsfoot trefoil which supplied from 5 to 10 percent more of the total association plot yields in 1953 than in 1952. Where trefoil was grown alone the encroachment of weeds decreased the percent of plot yield supplied by the trefoil.

PERCENT OF YIELD SUPPLIED BY TREFOIL FRACTION
(Mean of all plots)

YEAR	ASSOCIATION			
	Alone	Climax Timothy	Late Finnish	Orchardgrass
1952	64	45	38	
1953	56	50	48	

Title: TIME OF SEEDING AND RESPONSE OF FORAGE SEEDLINGS TO CLIMATE

Leaders: K. E. Varney and A. R. Midgley and Earl Stone (in cooperation with V. G. Sprague of the Pasture Research Laboratory)

Studies were started in 1953 to determine the relative value of hard and soft (permeable) seed for fall plantings of legumes. Plantings of hard and of soft birdsfoot trefoil seed were made at six different dates during summer and fall. Results indicate that stands from plantings made after August 15 were obtained entirely from hard seed. Stand counts for the June and July hard seed were believed to be low (see table) because of rather severe shading from the adjacent soft seed plants. The soft seed germinated shortly after planting whereas the hard seed did not germinate until the following spring.

RELATION OF PLANTING DATE TO THE SURVIVAL OF BIRDSFOOT TREFOIL FROM HARD AND SOFT SEED

DATE PLANTED 1952	No. of plants, September 15, 1953	
	From 100 Hard Seed	From 100 Soft Seed
June 15	18	38
July 15	25	41
August 15	43	27
Sept. 15	43	0
Oct. 15	43	0
Nov. 15	34	0

A very successful stand of birdsfoot trefoil was obtained by seeding unscarified seed in the fall in alternate rows with winter wheat. Plants from "soft" seed that started growth that fall died but the "hard" seed gave a good stand. They were much ahead of spring seeding.

Title: FACTORS AFFECTING THE VALUE OF PASTURE RANGE FOR CHICKENS

Leaders: G. M. Wood, D. C. Henderson, and H. C. Whelden

Preliminary studies concerning chicken preferences for various forages were initiated in 1953. Four separate trials were conducted and data collected showing that the chickens had definite likes and dislikes with respect to forage. The following table was drawn up from the results obtained. The species fell into rather distinct groups.

PREFERENCE RATINGS OF SEVERAL FORAGES AS CHICKEN PASTURE

HIGH	MEDIUM	LOW
smooth bromegrass	Ky. bluegrass	weeds *
orchardgrass	Reed canarygrass	birdsfoot trefoil
Ladino clover	redtop	
alfalfa		
tall fescue		
rye grass		

* Consisting of chickweed, Galinsoga, shepherds purse, dandelion and annual grasses.

Some of the grasses and legumes were grown in association as well as alone. In general more of a mixture of two palatable species was consumed than of either alone. Very little of an association of birdsfoot trefoil-bromegrass was consumed although bromegrass was one of the most palatable species tested. Birdsfoot trefoil was the least palatable of the forages tested.

Title: FACTORS AFFECTING THE ESTABLISHMENT AND MAINTENANCE OF BIRDSFOOT TREFOIL ON (A) PANTON CLAY SOIL AND ON (B) ADAMS LOAMY FINE SAND

Leaders: A. R. Midgley and K. E. Varney

Plots established in 1946 were harvested for the 6th consecutive year. Yields on the clay have continued to hold up -- in contrast to what would have been the case with other legumes on this soil.

One set of plots was renovated by fall disking and planting to winter wheat. An excellent stand of birdsfoot trefoil was obtained from the reservior of seed in the soil. At the same time a good yield of wheat was obtained.

WEST VIRGINIA

Title: ALFALFA BREEDING

Leaders: Dale A. Ray and O. J. Burger

In an effort to find suitable parental material for the initiation of an alfalfa breeding program, 18 new foreign introductions, 5 representative plants collected from a sample of fields of alfalfa that have persisted for ten or more years in West Virginia and 9 commercial varieties that are recommended in the Northeast Region are being evaluated in a preliminary observational nursery and in the greenhouse. Two introductions from Peru with pubescent stems and leaves appear to resist leaf hopper damage but are susceptible to winter injury. Several collections provide promise in regard to seed setting and leaf density. The materials are being observed in the field for differences in vigor, winter-hardiness, disease and insect resistance, flowering index and other general agronomic characteristics. Superior materials will be incorporated in a breeding nursery, and the inheritance of selected morphological characters will be studied.

Title: THE INFLUENCE OF FERTILITY AND MANAGEMENT ON SEVERAL LADINO CLOVER-GRASS MIXTURES.

Leaders: O. J. Burger, C. Sperow, and D. R. Browning

Ladino clover and various grasses were seeded in the spring of 1951. Ladino clover was seeded alone and in association with Kentucky 31 fescue, Lincoln bromegrass, Beltsville orchardgrass, and Reed canarygrass. Four fertilizer treatments were applied in March of 1952 and again in 1953. These were check, 800 pounds 0-10-0, 800 pounds 0-10-10, and 800 pounds 5-10-10. Three management treatments were imposed on all mixtures and fertilizer treatments to simulate pasture cut, intermediate cut and hay cut.

Delaying the first harvest, corresponding to the hay cutting, decreased the yield of the Ladino clover fraction. In 1953, the hay management plots produced a greater yield than those managed to simulate grazing. This was because there was less Ladino clover in the hay plots and more grass component.

The grasses offering the least competition to Ladino clover were bromegrass and Reed canarygrass. Orchardgrass and Kentucky 31-fescue offered the most.

Considering the Ladino clover plus grass fractions, the 5-10-10 treatment gave the highest yields, whereas the 0-10-10 produced the greatest yield of Ladino clover fraction.

Title: ATLANTIC ALFALFA SEED SOURCE TESTS

Leader: O. J. Burger

Sixteen entries of alfalfa replicated four times, were seeded May 1, 1952. The plots were cut for hay, starting June 8, 1953. The entries, with the total yield of three cuttings are listed below:

Class of seed	Source	Age of Stand	Yield 3 cuts Tons 12% Hay	Rank
Foundation	California	3	2.39	3
Certified	Utah	7	2.26	6
Certified	California	2	2.09	11
Breeder's	New Jersey	12	2.48	1
Certified	Utah	3	2.00	13
Certified	Utah	6	2.15	9
Certified	Utah	7	1.94	16
Certified	Texas	2	2.41	2
Certified	Utah	2	2.21	7
Registered	Utah	8	2.17	8
Kansas Common	Kansas	-	2.13	10
Certified	California	2	2.08	12
Foundation	Wyoming	-	2.32	5
Certified	Utah	4	2.36	4
Certified Buffalo	Kansas	5	1.99	14
Certified Ranger	Idaho	5	1.97	15
Average				2.18
C.V.%				9.59

Statistical analysis revealed no significant difference between varieties either on the individual harvest or on the season total basis. It is interesting to note, however, that the New Jersey's Breeders Seed from a 12 year old stand ranked first in yield.

Title: PERFORMANCE AND ESTABLISHMENT OF STRAINS AND VARIETIES OF SMOOTH BROMEGRASS IN WEST VIRGINIA

Leaders: O. J. Burger and F. W. Glover, Jr.

In 1951 the bromegrass strains and varieties of Lincoln, Achenbach, Fischer, Elsberry, Oklahoma #1, Oklahoma Synthetic, Manchar, Martin, Lancaster and Lyon and Northern Commercial were seeded with alfalfa at several locations throughout West Virginia.

Oklahoma Synthetic ranked consistently first in yield in both 1952 and 1953. This strain is now the named variety Southland.

Fisher, Lincoln, Achenbach and Manchar were the other varieties performing very well over the State.

Title: THE ESTABLISHMENT AND TESTING OF GRASS AND LEGUME SPECIES AND STRAINS FOR SOIL CONSERVATION

Leaders: O. J. Burger and Frank Glover, Jr.

The sericea lespedeza seeded in 1952 was grazed in 1953. Because the animals were not turned in early, the sericea (12 inches tall) was not consumed. The forage was cut for hay which was readily consumed.

General observations on Empire, European and Narrowleaf birdsfoot trefoils are as follows:

1. Emergence - Narrowleaf first, followed by European and Empire in that order.

2. Type of Growth - Narrowleaf, procumbent, Empire, procumbent to decumbent, European, upright although quite variable.

3. Yielding Ability - European, first, followed by Empire and Narrowleaf.

4. Maturity - Narrowleaf, European and Empire. However, European begins growth earliest in spring.

5. After drought period all birdsfoot trefoils made faster recovery than any species in the pasture.

6. Narrowleaf did not make very good growth on wet sites.

7. Birdsfoot trefoil grown with Kentucky 31 fescue appears to be a very good compatible mixture.

LIST OF PUBLICATIONS

Ahlgren, G. H., H. D. Gross, and M. A. Sprague. Bromegrass in New Jersey. N. J. Agr. Expt. Sta. Bul. 766. 1953.

Atwood, Sanford S. and James L. Brewbaker. Incompatibility in autoploid white clover. Cornell Univ. Memoir 319. July, 1953.

Battle, W. R. Effect of advance in generation and age of stand on bacterial wilt reaction of Atlantic alfalfa. Agron. Jour. 44: 602-605. 1952.

Binger, H. P. The hemicelluloses of orchardgrass. Ph.D. Thesis. The Pennsylvania State University. 1953.

Brewbaker, James L. and Sanford S. Atwood. Incompatibility alleles in polyploids. Proc. Sixth International Grassland Congress 1: 267-272. 1952.

Brewbaker, James L. and Wayne F. Keim. A fertile interspecific hybrid in Trifolium. The Amer. Nat. 87: 323-326. 1953.

Bubar, J. S. The effects of nitrogen fertilization and rates and methods of seeding on grass seed yields. M.S. Thesis. The Pennsylvania State University. 1954.

Burger, A. W. Pasture mixtures for beef production. Md. Agr. Expt. Sta. Bul. 444. 1953.

Burrage, R. H. and George G. Gyrisco. Control of European chafer damage in pasture sod-II. Jour. Econ. Ent. 46(1): 142-146. 1953.

Clarke, M. F. A study of the carotene and protein content of orchardgrass (Dactylis glomerata L.). I. Variation due to stage of growth, cutting management and clones. Can. Jour. Agr. Sci. 33: 184-194. 1953.

_____, A study of the carotene and crude protein content of orchardgrass (Dactylis glomerata L.). II. Heritable variation. Can. Jour. Agr. Sci. 33: 246-253. 1953.

Cleveland, R. W. Cytogenetic studies of hybrids between tetraploid Medicago sativa L. and diploid Medicago falcata L. Ph.D. Thesis. University of California. 1953.

Crowder, Loy V. A survey of meiotic chromosome behavior in tall fescue grass. Amer. Jour. Bot. 50: 348-354. 1953.

Fortmann, H. R. Performance of varieties of grass and legume species in Pennsylvania in 1952. Penna. Agr. Expt. Sta. Progress Report No. 105. June, 1953.

_____. Responses of varieties of bromegrass (Bromus inermis Leyss) to nitrogen fertilization and cutting treatments. Cornell Univ. Memoir 322. 1953.

Frans, R. E. and M. A. Sprague. Chemical control of Kentucky bluegrass. Agron. Jour. 45: 121-122. 1953.

Fribourg, Henry A. and W. Keith Kennedy. The effect of rates of seeding on the yield and survival of alfalfa in meadow mixtures. Agron. Jour. 45: 251-257. 1953.

Graham, J. H. Reaction of red clover strains to Stemphylium sarcinaeforme. Plant Dis. Reporter 37: 95-96. 1953.

_____. A disease of birdsfoot trefoil caused by a new species of Stemphylium. Phytopathology 43: 577-579. 1953.

_____ and R. G. Hanson. Field inoculation of red clover with Sclerotinia trifoliorum. Plant Dis. Reporter 37: 518-520. 1953.

_____ and V. G. Sprague. The effects of controlled periods of high and low humidities on the development of purple leafspot of orchardgrass. Phytopathology 43: 642-643. 1953.

Hanson, A. A., J. H. Graham, and K. W. Kreitlow. The isolation of Ladino clover plants resistant to Sclerotinia trifoliorum. Can. Jour. Agr. Sci. 33: 84-90. 1953.

_____ and Helen D. Hill. The meiotic behavior of hexaploid orchard grass (Dactylis glomerata L.). Bul. Torrey Bot. Club 80: 113-122. 1953.

_____ and V. G. Sprague. Heading of perennial grasses under greenhouse conditions. Agron. Jour. 45: 248-251. 1953.

Henderson, D. C., H. C. Whelden, Jr., and G. M. Wood. Range and confinement rearing of poultry. Vt. Agr. Expt. Sta. Bul. 568. 1953.

Hesse, Walter H. The effect of herbicides on the drying rate of hay crops. M.S. Thesis. Cornell University. 1954.

Johnson, Cornwin M. The influence of some soil and crop management practices on the Ladino clover content and the yield of some Ladino clover-grass mixtures. Ph.D. Thesis. Cornell University. 1953.

Kennedy, W. K. and K. R. Allred. Are silage preservatives good buys? Farm Research 19(2): 11. 1953.

_____ and R. U. Schenk. Hay and grain preservatives not reliable. Farm Research 19(2): 10. 1953.

Knight, W. E. Breeding Ladino clover for persistence. Agron. Jour. 45: 28-31. 1953.

_____. Interrelationships of some morphological and physiological characteristics of Ladino clover. Agron. Jour. 45: 197-199. 1953.

Kreitlow, K. W., J. H. Graham and R. J. Garber. Diseases of forage grasses and legumes in the Northeastern States. Penna. Agr. Expt. Sta. Bul. 573. 1953.

Land, C. E., Jr. Comparisons of the amounts of sugars and nitrogenous compounds in certain legumes with special reference to bloat in ruminants. M.S. Thesis. The Pennsylvania State University. 1953.

Midgley, A. R. and K. E. Varney. Permanent hayfields without plowing. Vt. Agr. Expt. Sta. Bul. 572. 1953.

Moran, C. H., V. G. Sprague and J. T. Sullivan. Changes in the carbohydrate reserves of Ladino white clover following defoliation. Plant Phys. 28: 467-474. 1953.

Murphy, R. P. Comparison of different types of progeny in evaluating breeding behavior. Proc. Sixth International Grassland Congress 1: 320-326. 1952.

_____, and S. S. Atwood. The use of I_1 families in breeding smooth bromegrass. Agron. Jour. 45: 24-27. 1953.

Nittler, L. W. A study of the response of alfalfa varieties to fertilizer treatments. Ph.D. Thesis. Cornell University. 1953.

Pettem, F. D. The heritability of seedling vigor in alfalfa. Ph.D. Thesis. Rutgers University. 1953.

Plummer, B. E. Chemical composition of grasses and legumes in Maine. Maine Agr. Expt. Sta. Bul. 513. 1953.

Roberts, Daniel A., Karl D. Fezer, and Robert T. Sherwood. Diseases of forage crops in New York, 1953. Plant Dis. Reporter 37 (in press). 1954.

_____, Robert T. Sherwood, and Karl D. Fezer. Diseases of forage crops in New York, 1952. Plant Dis. Reporter 36: 416-418. 1952.

Robinson, R. R., Leo J. Cotnoir, Jr., C. H. Moran, E. R. Purvis, W. A. Mitcheltree, H. G. Albritten, Irene H. Stuckey, and Milton Salomon. Soil fertility levels of grassland in some dairy sections of the Northeast. Agron. Jour. 45: 372-376. 1953.

Smith, D. L. Variation and inheritance of Beta-carotene in alfalfa. Ph.D. Thesis. Cornell University. 1953.

Sprague, M. A. Pasture renovation with the aid of chemicals. Proc. Northeastern Weed Control Conference, New York City. 1953.

Sprague, V. G. Maintaining legumes in the sward. Proc. International Grassland Congress, 443-449. 1952.

Sprague, V. G., Chairman Pasture Improvement Committee, Amer. Soc. Agron. Recommendations for reorganization to grassland improvement steering committee. Agron. Jour. 45: 647. 1953.

Sullivan, E. F. Studies concerning the fertilization of existing grass and legume-grass meadows, and the establishment of new legume-grass leys on soils of the St. Lawrence Plain area of New York. Ph.D. Thesis, Cornell University. 1953.

Sullivan, J. T. and V. G. Sprague. Reserve carbohydrates in orchardgrass cut for hay. Plant Phys. 28: 304-313. 1953.

Taylor, N. L. Inheritance of resistance to the potato leafhopper in alfalfa. Ph.D. Thesis. Cornell University. 1953.

Varney, K. E. Trefoil is different. Better Crops with Plant Food 37(5): 13-16 and 43-44. 1953.